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Macroeconomic policy and farmland value: a dynamic, portfolio-balance approach

Alan Dean Barkema
Iowa State University

Barkema, Alan Dean

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Macroeconomic policy and farmland value:

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Alan Dean Barkema

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CHAPTER ONE: A HISTORICAL PERSPECTIVE OF U.S. FARMLAND VALUE

The Significance of Farmland Value in the Agricultural Sector

The farming sector of the United States economy entered a period of wrenching financial adjustment as the decade of the 1980s began, and the adjustment process has continued unabated through the first half of the decade. One measure of the significance of the current financial crisis confronting farmers, agricultural businessmen, and rural communities as well as professional agricultural economists is found in the program of the annual meeting of the American Agricultural Economics Association (AAEA) held at Iowa State University in August, 1985. Two invited paper sessions and one selected paper session were addressed directly to issues of farm and rural community adjustment and survival under conditions of financial stress. An additional four selected paper sessions were devoted to farm management topics closely associated with the ongoing financial crisis in agriculture.

Several factors playing a significant role in bringing about the financial adjustment in the farming sector during the first half of the 1980s can be found in changes occurring in the sector's aggregate balance sheet during the preceding three decades. As shown in Table 1.1, the total value of all assets committed to agricultural production increased three-fold during the 1970s and more than five-fold from 1960 to 1980. The liquidity of the assets side of the sectoral balance sheet declined, however, as asset values increased. The proportion of total assets held

Table 1.1. Aggregate balance sheet data for U.S. agriculture[a]

Item	1950	1960	1970	1980	1981	1983	1984
	Year						
Total assets ($\$10^9$)	154	211	326	1108	1111	1061	956
Asset components (%)							
Financial	10.4	8.4	7.4	3.9	4.1	4.7	5.6
Nonreal estate	31.6	25.8	24.2	19.8	19.7	20.1	21.8
Real estate	58.0	65.7	68.5	76.4	76.2	75.2	72.6
Total debt ($\$10^9$)	13.0	26.2	54.5	182.3	202.1	216.2	212.5
Debt/asset ratio (%)	8.5	12.4	16.7	16.5	18.2	20.4	22.2
Debt/NFI ratio	1.0	2.3	3.8	9.0	6.8	14.4	6.2

[a]From Economic Indicators of the Farm Sector, various years. Operator households included.

as real estate increased from less than 60 percent in 1950 to more than 75 percent in 1980, and the proportion of assets held as financial reserves declined from more than 10 percent to less than 4 percent during the same period.

The last three lines of Table 1.1 provide additional preliminary evidence regarding the factors responsible for the financial stress found in the farming sector in the 1980s. The stock of debt shown on the sector's balance sheet increased even more rapidly than did asset values from 1950 through 1981 resulting in an increase in the average debt-to-asset ratio (DAR) from 8.5 in 1950 to 18.2 in 1981 and to 22.2 by 1984. As the sector's leverage position as measured by the DAR increased, current income available to service each dollar of accumulated debt declined as shown by the increase in the debt-to-net-farm-income ratio from 1.0 in 1950 to a range from 6.2 to 14.4 in the 1980s.

This review of changes in agriculture's balance sheet indicates that a reduction in asset liquidity, an increase in the sector's financial leverage, and an increase in the debt-to-net-farm-income ratio left the sector in a vulnerable financial position as the 1970s drew to a close. Any substantial shortfall in current returns to assets would result in difficulty in servicing a large stock of debt, a problem which could not readily be resolved with a diminished financial asset reserve (Barkema, 1985; Barkema and Doye, 1985; Doye, 1986).

Melichar (1986) has shown that even though farming has, in the aggregate, remained a profitable venture during the 1980s, income from assets has declined substantially from peaks recorded during the years

1972 through 1975 and 1978 through 1979. Indeed, during the period 1980 through 1984, income from assets was on average just sufficient to cover the interest expense on the sector's substantial debt load (Table 1.2). Those farmers with above average levels of debt have found themselves in the predicament of being unable to meet debt service obligations from current earnings, a situation which dictates the sale of assets in order to reduce the debt burden assumed in acquiring them.

The importance of the role of a sharp decline in agricultural land value in the financial adjustment currently taking place in the farming sector is apparent. The average value of an acre of farm real estate in the United States fell 19 percent from April 1, 1981, to April 1, 1985, and 12 percent during the year from April 1, 1984, to April 1, 1985. The corresponding values for the state of Iowa, which has experienced the largest decline in farm real estate value among all states during both periods, are 49 percent and 29 percent, respectively (Agricultural Land Values and Markets Outlook and Situation, 1985).

Because real estate is the largest single component of the sector's balance sheet comprising approximately 75 percent of the value of all assets committed to farming on the national level as well as in the state of Iowa, swings in real estate values play a large role in the financial well-being of the farming sector. Indeed, the predominant position of real estate on the sector's balance sheet takes on even greater significance during times when the liquidation of assets to meet debt service obligations is necessary. In a period of declining real estate values attempts to finance short-term cash shortfalls through borrowing against equity in assets or through selling assets outright are frustrated.

Table 1.2. Aggregate income statement data for U.S. agriculture[a]

Item		Period 1970-71	1972-75	1976-77	1978-79	1980-84
		--Annual average, billions of 1984 dollars-				
Gross income		134	173	162	184	161
Less:	Operating expenses	76	90	96	104	94
Equals:	Cash flow before interest	58	83	66	80	67
Less:	Depreciation	14	17	20	22	21
Less:	Imputed return to operators' labor and management	31	30	29	29	24
Equals:	Income from assets	13	37	16	29	22
Less:	Interest	8	10	12	16	21
Equals:	Income from equity	5	27	4	14	1

[a]From Melichar (1986).

Nominal and real U. S. agricultural land values are plotted in Figure 1.1. The index of nominal U.S. land value is derived from that published by the U.S. Department of Agriculture (Agricultural Statistics, various years; Farm Real Estate Market Developments: Outlook and Situation, various years), and the index of real U.S. land value is obtained by deflating nominal values by the implicit price deflator for GNP found in Reagan (1985). A peak in U.S. farmland value in constant 1972 dollars as well as current dollars occurred in 1920 to 1921 and was followed by a sharp decline to a market low in the early 1930s during the depths of the major depression of that era. Following nearly forty years of generally steady and gradual appreciation in value, a sharp increase in value in both nominal and real terms began in the early 1970s and ended in 1981. The aggregate averages for the United States as a whole show that a substantial portion of the real wealth gain accruing to land owners during the 1970s has been lost since 1981.

Dissertation Objectives

The objective of this dissertation is to investigate the causes of the extraordinary swings in agricultural land values in the United States during the 1970s and early 1980s as noted in Figure 1.1. Specifically, hypothetical causal relationships between events in the general economy and changes in the value of farm real estate will be identified within an appropriate theoretical framework and tested empirically.

The investigation is initiated in the second section of this chapter with the observation of macroeconomic events which appear to be

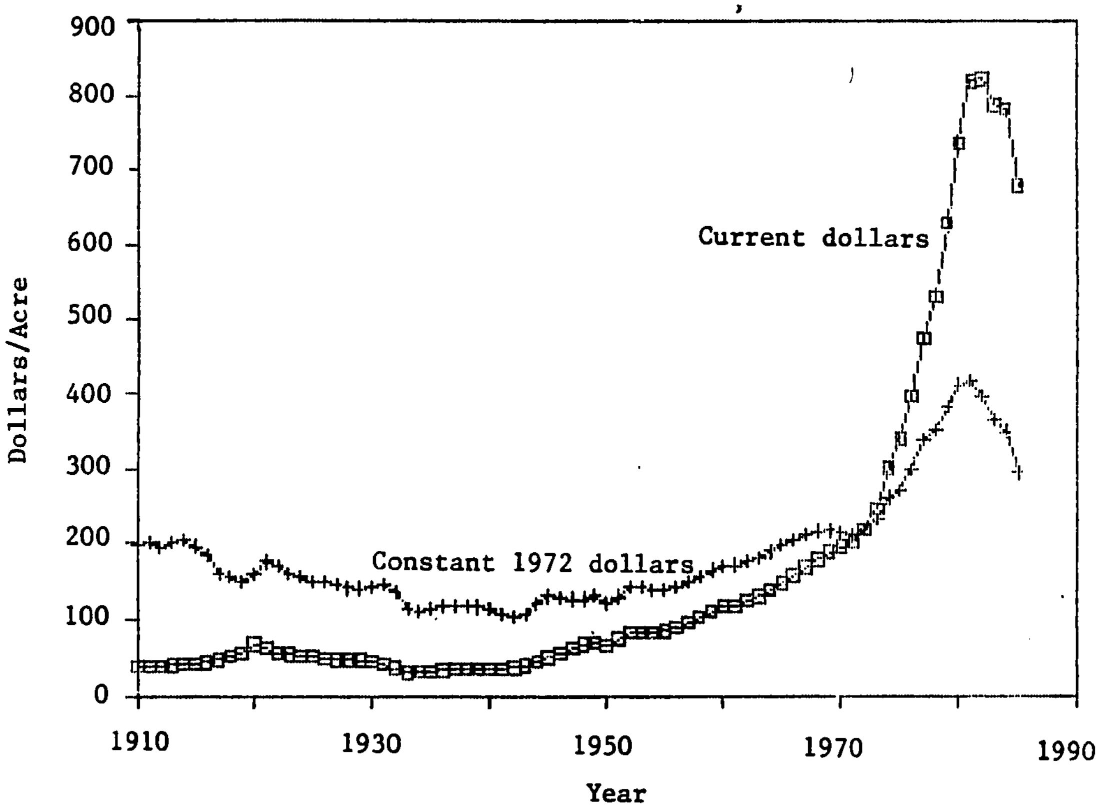

Figure 1.1. Average U.S. land value in nominal and real terms

associated with events in the market for farmland. Following the observation of these data, the hypothesis around which the remainder of the dissertation is built is proposed. Chapter One concludes with a review of previous land value studies to provide the perspective necessary for relating this study to the progression of thought found in the literature of agricultural economics.

The income-capitalization model of land value is discussed in considerable detail in Chapter Two to provide a starting point for determining how macroeconomic policy could affect land value through changes in the rate of discount applied to a future income stream expected to accrue to the land owner. The focus of the dissertation narrows in Chapter Three to provide a closer scrutiny of the role that the discount rate and, more specifically, the real rate of interest play in the determination of the price of farmland. The conceptual model providing the theoretical relationships between monetary policy and the value of farmland is developed in the latter sections of Chapter Three, and the model is expanded to include the effects of fiscal policy in Chapter Four. Chapter Five provides a review of the econometric techniques which are used in the empirical test of the theoretical model. The results of the empirical test are provided in Chapter Six, and a summary of the entire study is found in Chapter Seven.

An Initial Hypothesis

The inflation rate and nominal interest rate since 1930 are plotted in Figure 1.2. The measure of inflation used in Figure 1.2 is the annual

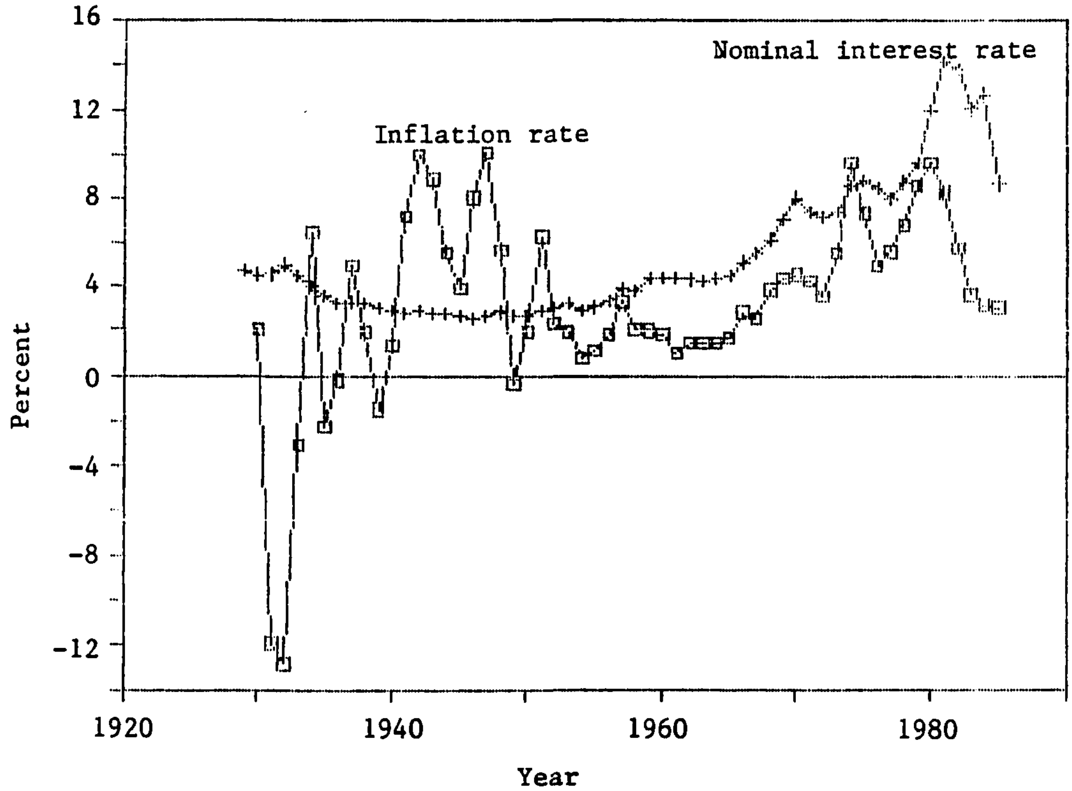

Figure 1.2. The rate of inflation and the nominal rate of interest

percentage change in the implicit price deflator (IPCE) for the personal consumption expenditures component of GNP approximated by the first difference of the natural logarithms. The nominal interest rate shown is the yield on Moody's grade Aaa corporate bonds.[1] Most notable in this chart are two periods of rapid growth in the inflation rate which occurred in 1972 to 1974 and 1976 to 1980. The nominal interest rate did not respond quickly to the increase in the rate of inflation during the early 1970s, but as the growth in the inflation rate slowed beginning in 1980, the nominal interest rate shot to its 1981 peak. Both rates declined substantially following the 1981 high.

The data of Figure 1.2 are summarized in Figure 1.3 by plotting the ex-post real rate of interest or the difference between the nominal interest rate and the rate of inflation. Of special interest in this plot are the periods from 1973 to 1979 and from 1979 to 1985. During the first of these periods the real rate of interest in two separate moves declined to levels below the long-term average rate recorded during the previous two decades. In the latter period, the real rate climbed rapidly to a high in 1984 at a level three times that of the long-run average of the previous three decades.

Comparison of Figures 1.1 and 1.3 shows that the land price explosion of the 1970s occurred during a period when the real rate of interest was generally below its long-run average value, and the land market collapse of the 1980s occurred as the real rate of interest rose

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[1] The data series plotted in Figures 1.2 to 1.5 are described in detail in Chapter Five.

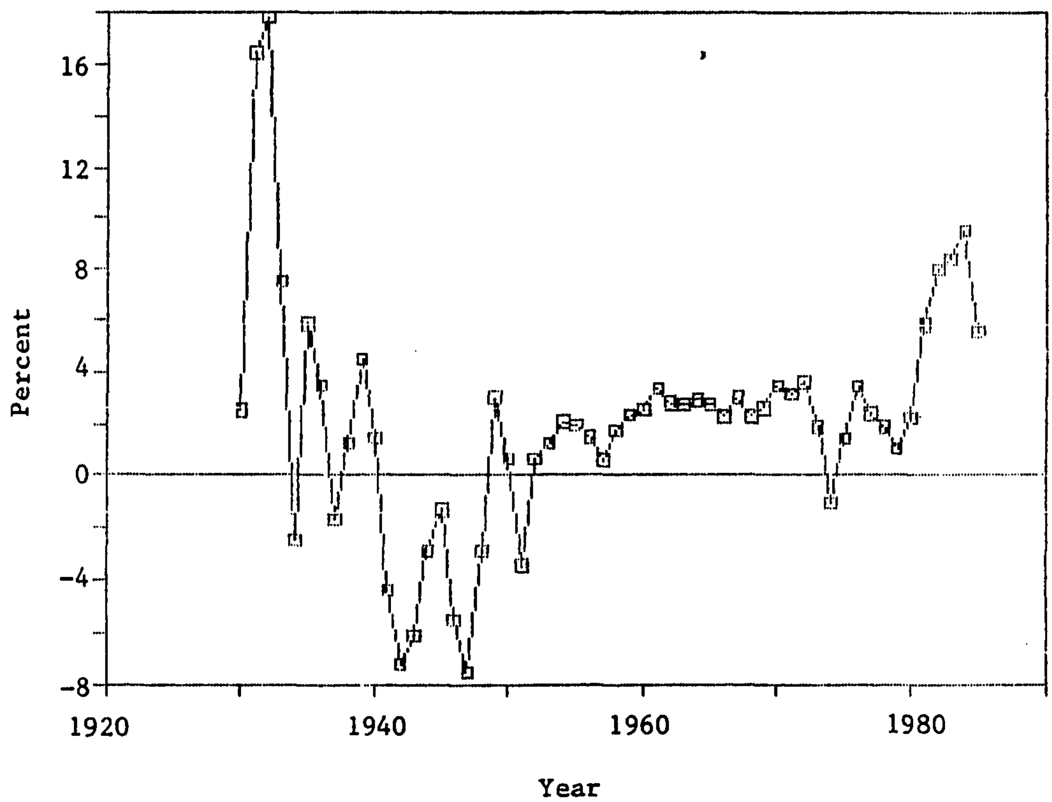


Figure 1.3. The ex-post real rate of interest

to extraordinarily high levels. This simple observation is the basis for the first part of the hypothesis upon which this dissertation is based. That is, swings in the real rate of interest have been a factor in the boom-and-bust cycle of the agricultural land market of the 1970s and 1980s. Moreover, land values are inversely associated with the real rate of interest.

The second and final part of this initial hypothesis is derived from observation of Figures 1.4 and 1.5. Figure 1.4 is a plot of the annual percentage change, approximated by the first difference of the natural logarithms, in the money supply as measured by the monetary aggregate M1 from 1930 to 1984. This chart indicates that monetary growth after World War II has been quite stable relative to the record of the earlier period. Nonetheless, considerable variation around a slight positive trend in the annual rate of money growth has existed since the early 1950s.

Basic macroeconomic theory suggests that a positive association exists between the rate of expansion of the money supply and the rate of inflation (Starleaf, 1979). The M1 growth and inflation data for the 1970s generally support this theory. The increasing rates of inflation of the earlier and later years of the 1970s are associated with increasing rates of growth of M1, and the sharp decrease in the rate of inflation in 1974 is associated with a decline in the rate of expansion in M1 in the mid-1970s. Likewise, the decline in the rate of inflation beginning in 1981 is preceded by a reduction in the rate of increase in M1 growth beginning in 1979. A comparison of the plot of the real rate

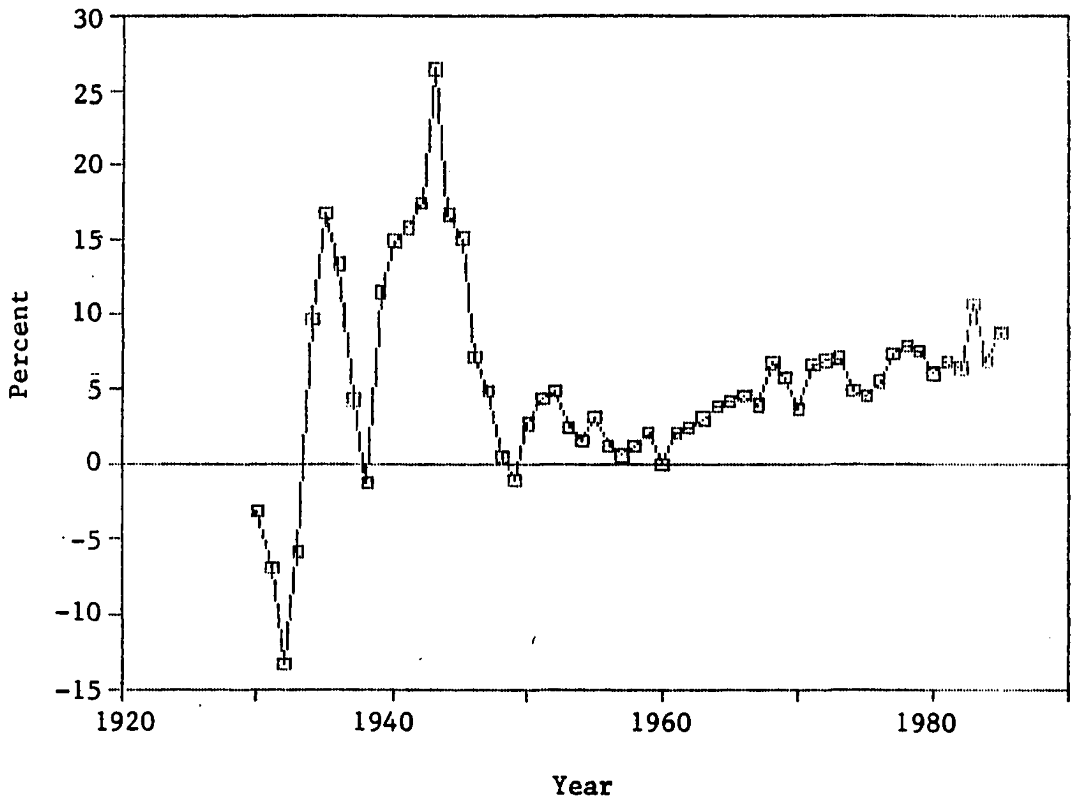


Figure 1.4. The annual rate of M1 growth

of interest (Figure 1.3) with that of Figures 1.2 and 1.4 suggests that increases (decreases) in the rate of monetary expansion are associated with increases (decreases) in the rate of inflation and decreases (increases) in the real rate of interest.

Figure 1.5 is a plot of the annual fiscal deficit of the United States government as recorded in the National Income and Product Accounts from 1929 to 1985 and stated in real terms by deflating by the IPCE. These data show that a period of substantial real deficit spending during the depression years of the 1930s and the war years of the 1940s was followed by nearly two decades of alternating surplus and deficit. The record of the most recent two decades, however, is one of generally increasing real deficit spending. Especially noteworthy is the pattern of real deficit spending from 1971 to 1984, a pattern which nearly matches that of the real interest rate during the same period in Figure 1.3. These data suggest that a high (low) real rate of interest is associated with a large (small) real fiscal deficit.

The hypothesis which was stated in part in an earlier paragraph can now be completed. The first part of the hypothesis was that the value of farmland is inversely associated with the real rate of interest. The complete hypothesis is that monetary and fiscal policy affect land value by causing shifts in the real rate of interest. More specifically, the real rate of interest can be expected to rise and land values can be expected to decline during a period of expansionary fiscal policy and restrictive monetary policy as seen in the 1980s. The converse is also true as seen in the boom years of the land market of the 1970s.

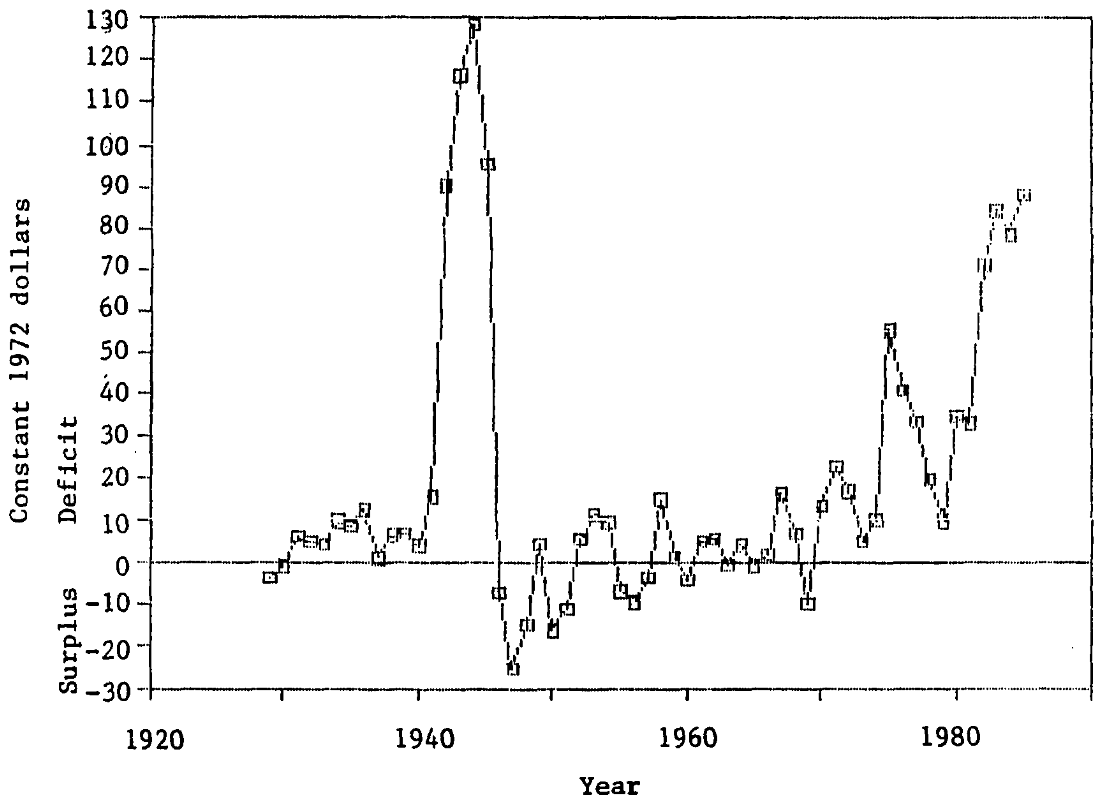


Figure 1.5. The real fiscal deficit of the U.S. government

An explanation of the apparent relationships among the data of Tables 1.1 and 1.2 and Figures 1.1 through 1.5 is found in the hypothesis of portfolio-balancing behavior of wealth holders, a hypothesis which will be developed in detail in the chapters which follow. During the period of below normal real returns on financial assets and above normal returns on farm production assets during the 1970s, investors shifted their asset holdings from financial assets toward real assets. Indeed, many investors went short in the financial asset market--that is, they borrowed money--to increase their holdings of real assets. A fundamental shift in macroeconomic policy, however, occurred abruptly as the 1970s ended. Large fiscal deficits accompanied by a policy of monetary restraint drove the real rate of return on financial assets to extraordinarily high levels. The optimal portfolio under the new macroeconomic environment of the 1980s was a portfolio containing a greater proportion of financial assets and a smaller proportion of real assets than the optimal portfolio of the 1970s. The large downward adjustment in farmland value in the first half of the 1980s was necessary to bring the rate of return on an investment in land into line with the rate of return available from an investment in financial asset alternatives.

Although the focus of this dissertation is the hypothesized linkage between macroeconomic policy and the value of farmland, the hypothesis does not state that macroeconomic policy is the only cause of the extraordinary events in the farmland market of the past fifteen years. One notable omission from this investigation is the consideration of the economy of the world beyond the borders of the United States. The capitalization of expectations of a growing income stream accruing to domestic farm production assets as a result of an expansion of agricultural exports from the United States during the 1970s is one apparent factor causing an increase in farmland value during that period. An equally apparent factor entering the farmland market in the 1980s is a 34 percent reduction in export volume of major agricultural products from 1980 to 1985 resulting in the reversal of the expectations established during the 1970s and serving as a contributory cause of the decline in farmland value (Drabenstott and Norris, 1986; Hathaway, 1986).

One could argue that these events associated with the rest of the world are not independent from domestic macroeconomic policy. The linkage usually suggested runs from macroeconomic policy to interest rates to capital flows to exchange rates to export flows to domestic commodity prices to farmland value. Although the conceptual model developed in this study does not explicitly address the influence of the rest of the world in the United States farmland market, brief consideration is given to these effects in the empirical testing of the theoretical model.

The theoretical models developed in the following chapters are designed to determine how domestic macroeconomic policy can affect farmland value, and the empirical test described in the final chapter is designed to determine the direction and extent of influence of macroeconomic policy on farmland value as revealed in a more rigorous scrutiny of the data examined in this chapter. Portfolio-balancing behavior is a fundamental part of each member of the sequence of analytical models developed in the remaining chapters of this study. In the following section of this chapter, approaches to the study of the land market that previous researchers have pursued are reviewed. At the conclusion of Chapter One, the relationship between the portfolio-balance approach to the study of farmland value and the larger body of land-value literature should be apparent.

A Review of Previous Land Value Studies

The primary purpose for including this section of Chapter One is to trace the development of scientific inquiry into the factors affecting the market for farmland with specific attention given to major changes in direction which have occurred in this area of research over time. This brief review of previous studies of factors affecting the market for farmland emphasizes those investigations having an immediate bearing on the focus of this study; this review is not intended to be an exhaustive summary. The work of Doll, Widdows, and Velde (1983a, 1983b) is recommended for the reader interested in a more exhaustive review.

Although the portfolio-balance model gained prominence in the literature of economics with Tobin's pathbreaking work (1969; Brainard and Tobin, 1968), direct application of portfolio-balance models to the study of the market for farmland in the United States is a more recent development. Nonetheless, the evolution of this application of the portfolio-balance model appears to be a natural outcome of the progression of thought which is evident in the land value literature of the past thirty years.

The income capitalization model of land value reviewed in the following chapter has been the fundamental model of land valuation since the days of Ricardo. In reviewing Ricardo's early work, Clark (1973) summarizes the principle upon which the income-capitalization model is based stating succinctly, "Land has value because it can earn a rent." Ricardo (1817) defined rent as "...that portion of the produce of the earth which is paid to the landlord for the use of the original and indestructible powers of the soil." In the discussion of his definition of rent, Ricardo recognized that two farms of equal size and natural fertility would command different remuneration if different levels of investment in fixed improvements, including added fertilizer, drainage structures, fences, and buildings, had been committed to the two farms. He noted, however, that only a portion of the money to be paid for the use of the improved farm could be included as return to land and defined as rent; the remainder is paid for the use of the capital improvements added to the land.

Another important concept embedded in the income-capitalization model is the fact that the supply of land is virtually fixed. Clark points out that given a fixed supply of land, "...the price will have to adjust itself to such a level that those who inescapably will have (collectively) to hold this stock will, in fact, be content so to hold it." Even at this earliest stage of thought about the determinants of land value, the rudiments of the portfolio-balance model are in place. Having carefully measured returns to land so that the measurement does not include returns to other factors, the investor will be content to pay a price for land such that the return on his investment in land is comparable to that available from some alternative investment. This comparison of returns to land--appropriately measured--with the returns available on alternative investments is precisely the function of the discount rate in the capitalization models of Chapter Two.

In retrospect, a portion of the effort expended in land value research during the 1950s and 1960s could have been saved had the authors of the period consulted Ricardo's concise and insightful statement on the determinants of land value. Researchers of the period did not entirely abandon the Ricardian concept of rent-determined value as shown by the inclusion of some measure of returns to land and a discount rate in their models. Much of the research of the period, however, was motivated by the observation that farmland value was increasing at a greater rate than farm income in a phenomenon called the land-price paradox. In an effort to resolve the so-called paradox, a search for other determinants of land value began.

In addition to measures of returns to land and a discount rate, Heady and Tweeten (1963), for example, included lagged farm size as a measure of demand for farm enlargement and a time trend as a proxy for technological advance in a single-equation, econometric model of the United States farmland market. Likewise, Tweeten and Martin (1966) used farm numbers and machinery stocks as proxies for the farm enlargement variable. They also suggested that one source of farm enlargement pressure was an excess supply of farm boys relative to farms available.

Another variable included as a determinant of land price was the capitalized benefits of farm price-support programs. Also notable in the Tweeten and Martin model is the inclusion of capital gains as a measure of speculative forces influencing land price change.

The model of Reynolds and Timmons (1969) captures much of the thought underlying land value research during the 1950s and 1960s. Citing the divergence of net farm income and land price which had occurred since 1950, the authors stated their intention of finding factors other than net farm income which influenced land prices. In addition, they noted that residual returns to land as a percentage of net farm income had increased since the early 1950s, an observation which appears especially insightful in view of Ricardo's emphasis on careful measurement of the residual return to land.

Elements of the Heady and Tweeten model and the Tweeten and Martin model are readily apparent in the model of Reynolds and Timmons. In addition to net farm income as a measure of returns to land and the average rate of return on 200 common stocks as the discount rate, Reynolds and Timmons included the number of farm transfers, the level of government payments, and expected capital gains as determinants of farmland price in the first equation of a two-equation, recursive model. The second equation determined the number of farm transfers as a function of expected capital gains, the ratio of farm to nonfarm wage rates, the ratio of farm mortgage debt to farm-sector equity, and a measure of technological advance, the number of man-hours of labor per acre.

More recent research has shown that the land-price paradox which developed after 1950 was more apparent than real. Melichar's work (1979) was instrumental in correcting not only the misconceptions which had led to the concern about the supposed paradox but also the errors in logic which had appeared in the models designed to explain the paradox. Melichar's paper emphasized two important points. First, he pointed out that returns to other factors of production must be excluded in the calculation of the residual return to farm production assets, the primary component of which is land, the same principle established nearly two-hundred years earlier by Ricardo. Secondly, he showed that a land price which diverges over time from returns to land, appropriately defined, is entirely consistent with the Ricardian concept of rent-determined value if one takes into account expected growth of the net return stream. Much of Chapter Two is devoted to a detailed development of this second point.

When viewed in the light of Melichar's restatement of Ricardo's theory of land value, the explanatory variables included in the three models reviewed above fall into four groups: 1) factors that are determinants of net returns to land, 2) the discount rate applied to the stream of net returns, 3) demand factors not related to land's productive return, and 4) measures of capital gain or land price appreciation itself. Capitalized benefits of government price support programs, for example, are certainly a form of net returns to land. Measures of technological advance affect the growth of the net return stream and can also be included in the first group. Factors in the third group include measures of urban encroachment and the excess farm boy variable of the Tweeten and Martin model.

The inclusion of variables measuring anticipated capital gains in these models is a practice which deserves a more critical evaluation. As will be shown in detail in the following chapter, land price increases arise from discrete or continuous increases in returns to land. The inclusion of both returns and capital gains as explanatory variables in a land price equation suggests that expected capital gains and the expected future net return stream are evaluated independently, a suggestion that is logically inconsistent with the asset valuation theory to be reviewed in greater detail in Chapter Two.

This logical inconsistency, however, has not inhibited authors from continuing to attempt to explain land price increases with land price increases. One notable example is the paper by Plaxico and Kletke (1979) which attributes value to discounted, unrealized capital gain. Castle and Hoch (1982) employ similar logic in capitalizing capital gain as well as net rents into the current value of land. In the summary comments following their detailed review of the land-value literature, Doll, Widdows, and Velde (1983a) criticize the incompleteness of previous land-value models stating, "...none has assembled a complete picture of farmland as a productive input, a consumption good, and a speculative portfolio asset." Their criticism of the exclusion of the value of land as a consumptive good from land value studies is probably well-placed, but the value of land derived from its use as a productive asset is not at all distinct from the value derived from its inclusion in speculative portfolios.

Recent Approaches to the Study of Land Value

Prior to 1980, the emphasis of land price research fell on the determinants of the stream of returns accruing to land rather than on the rate at which future returns were discounted. As discussed above, Melichar's decisive work (1979) emphasized the measurement of the residual returns accruing to land and the growth of the stream of returns over time. A series of papers by Feldstein (1980a, 1980b, 1980c), however, focused attention on the rate at which the net return stream is discounted.

More specifically, Feldstein's papers addressed the issue of the determination of asset prices in an inflationary economy. The primary issue in Feldstein's work was the interaction of price inflation and favorable income tax treatment of capital gains in determining the price of common stocks, gold, and land. The basis of Feldstein's research with regard to the price of land is that favorable taxation of capital gains accruing to land owners in an inflationary economy increases the rate of return on land relative to the return available on alternative investments, say money or interest-bearing bonds. The price of land is then bid to higher levels by portfolio managers serving as arbitrageurs in the assets markets with the result that the rate of return on the higher priced land is forced to a lower equilibrium level .

Even though a subsequent test found no empirical support for Feldstein's hypothesis (Martin and Heady, 1982), Feldstein's work did open the door to a new approach to land value research. Specifically, Feldstein's work placed a greater emphasis on the comparison of rates of return on alternative assets, the function performed by the discount rate in determining value from income capitalization. This emphasis on relative rates of return on alternative assets available for inclusion in the investor's portfolio is reflective of the work of Tobin and Brainard and Tobin completed a decade earlier. The key element in Tobin's portfolio-balance model was the inclusion of the entire vector of rates of return on alternative assets in the demand function for each of the assets in the investor's wealth portfolio. The simultaneous equation of demand and supply for each asset in Tobin's model determined rates of return on assets or alternatively, asset prices.

This new approach to land-value research is consistent with the recent development of interest in the linkages between events in the general economy and events in the agricultural sector. For example, Starleaf (1982) compared the performance of the farm sector and the nonfarm business sector of the United States economy during the post World War II period. He found that the nominal output of the farm sector was more variable than that of the nonfarm sector and that most of the variability in nominal output of the farm sector was due to price variation rather than quantity variation. More significantly, he observed a positive association between the price of farm output and the level of nonfarm output. He concluded that to the extent that macroeconomic policies had altered the output of the nonfarm sector, those policies had also had an effect on the price of farm output.

A related issue has been a source of considerable debate in the agricultural economics literature during the 1980s. The controversy is centered on the effects of inflation on the real price of farm output. Gardner (1981) could find little evidence of an effect of inflation on real farm-level prices. Tweeten's analysis (1983), however, indicated that inflation depressed the farm parity price ratio in the short run and had no effect on farmers' terms of trade in the long run. Starleaf, Meyers, and Womack (1985) found that the ratio of prices received to prices paid by farmers increased when the rate of inflation increased. In response to criticism of the Starleaf, Meyers, and Womack study by Belongia (1985b), Falk, Devadoss, and Meyers (1986) studied the direct impact of a monetary shock on farmers' terms of trade and found that the association between an unanticipated increase in money growth and the parity price ratio was positive.

Chambers' (1984) conceptual model and empirical test of the effects of monetary policy on the agricultural sector are in substantial agreement with the work of Starleaf, Meyers, and Womack and Falk, Devadoss, and Meyers. The short-run results of a restrictive monetary policy in Chambers' conceptual model were a reduction in the level of agricultural exports, the price of agricultural output relative to nonagricultural products, and the income of the agricultural sector. Chambers' detailed conceptual model and empirical test using recently developed vector-autoregression techniques appears to be in answer to Chambers' (1983) own call to agricultural economists to "...move forward to direct investigations of these matters and stop looking only at secondary effects with second-best techniques."

The recent interest of agricultural economists in the linkage between the general economy and the agricultural sector has to date been focused on the effects of monetary and fiscal policy on farm income. The consideration of the impacts of macroeconomic policy on the price of farmland is a natural step forward in this line of thought when one recalls that a major portion of farm income represents a return to farm real estate. Indeed, a series of three papers presented at the 1985 annual meeting of the AAEA indicates that at least one branch of current land price research is growing in that direction.

Featherstone and Baker (1985) investigated the relative impacts of changes in returns to farmland and changes in the discount rate on farmland price, but no explicit attention was given to tracing the source of the returns or discount rate shocks back to macroeconomic policy. Barkema and Doye (1985) provided a heuristic argument for the deleterious effects of a restrictive monetary policy acting in concert with an expansionary fiscal policy on the price of farm real estate. Their argument suggested that recent macroeconomic policies had caused an increase in the real rate of interest and a subsequent decline in the price of farmland in accordance with portfolio-balance concepts. Tweeten (1985b) established a similar heuristic argument relating macroeconomic policy to the value of the real rate of interest. In addition Tweeten provided data that showed a negative association between the real rate of interest and the average price of farmland in a sample of Great Plains states during the 1980s.

The objective of the following chapters is to extend the analysis of the impact of macroeconomic policy on the farm sector to a consideration of the effects of those policies on the price of agricultural land. The conceptual model developed to attain this objective is a dynamic, portfolio-balance model which represents an application of Tobin's approach to monetary theory to an issue broader in scope than the taxation problem considered by Feldstein. Hopefully, this new approach to an old problem will meet Chambers' challenge while providing the combination of theoretical framework and empirical analysis lacking in the preliminary investigations of Featherstone and Baker, Barkema and Doye, and Tweeten. Because the underlying logic of the portfolio-balance model is closely related to the determination of the discount rate and its role in the income-capitalization model, a discussion of those topics follows directly.

CHAPTER TWO: THE INCOME-CAPITALIZATION MODEL OF LAND VALUE

Although a broad range of variables has been chosen in previous research to explain changes in land value, most agricultural land value studies include some form of net income accruing to the owner of the land as one of the variables in determining the market price of the land. This fundamental relationship between income and value is specified in the asset valuation model of equations 2.1 and 2.2.

$$(2.1) \quad V(t) = \sum_{i=t}^{\infty} \frac{R_i}{(1+d)^{i-t}}$$

$$(2.2) \quad V(t) = \int_{\delta=t}^{\infty} R_t e^{-d(\delta-t)} d\delta$$

In this most general specification of the asset valuation model, the value of the asset at time t, V(t), is given by the sum of the net returns R(t) accruing to the asset, the return in each time period being discounted at the rate d. In the discrete form of the model (equation 2.1), annual compounding of interest is assumed, and in the continuous form of the model (equation 2.2), continuous compounding is assumed.

This general form of the model is typically made more restrictive by incorporating specific assumptions regarding the time sequence of net returns and additional assumptions regarding the discount rate. Reinsel and Reinsel (1979) include taxes and the rate of inflation in a list of the factors which could influence the stream of net returns. Melichar

(1979) emphasizes real growth of the net income stream. Harris (1979) allows for real growth of the net income stream and incorporates the rate of inflation and the rate of real growth in the denominator of the discrete model, a model specification which the derivations which follow show is not consistent with the model's underlying logic.

Using the continuous form of the model, Tweeten (1981, 1983, 1985a) and Bergland and Randall (1984) distinguish between nominal and real growth of the net income stream and show that the value of the asset is invariant to the length of the holding period prior to subsequent resale of the asset. Adams (1977) discusses the effect of a tax on income in the discrete form of the asset valuation model in the absence of either nominal or real growth of the net income stream. Finally, Robison, Lins, and VenKataraman (1985) incorporate the effects of a property tax and a capital gains tax in the discrete form of the model.

The model developed by Robison et al. is similar to the most detailed model of those to be discussed in the following paragraphs. The objective of Robison et al. was to study the market for agricultural and nonagricultural land by aggregating from the firm-level, income- capitalization model. The primary objective of this chapter, however, is the introduction of the basic components of a conceptual framework for investigating the linkages between macroeconomic policy and the price of farmland. This objective is approached by providing an integrated examination of the effects of real growth, nominal growth, and taxation of the next income stream on the value of land. Of particular importance to the development of the theoretical models which follow in Chapters Three and Four is the effect of macroeconomic policy on the real rate of interest, a component of the discount rate.

The remaining paragraphs of this chapter provide a derivation of the discrete form and the continuous form of the income capitalization model under three sets of assumptions or cases:

Case One: Inflationary growth of the net income stream

Case Two: Real growth of the net income stream

Case Three: Real growth and inflationary growth of the net income stream

The discussion of each case includes the effect of income taxes on asset value. The effect of a change in the planned length of the ownership period on the present value of the asset is considered in a concluding note. In the final section of the chapter, an analysis of an investment in Iowa farmland using realistic values of net returns, the discount rate, and the growth rate is provided as an example of the practical application of the income-capitalization model and as a means of demonstrating the numerical effects of changes in the parameters of the model on the value of farmland.

Case One: Inflationary Growth of the Net Income Stream

In this case assume that net returns to agricultural land increase over time at exactly the rate of nominal price level increase in the general economy, π percent. Also assume that the discount rate d is equal to the sum of the real rate of interest r and the rate of inflation

π. The real rate is determined by constant time preferences in consumption and alternative investment opportunities. Thus, assume that the discount rate is constant over time and that a full inflation premium is incorporated into the discount rate. Finally, assume that the rates d, r, and π refer to annual rates in the discrete form of the model and to continuous rates in the continuous form of the model.

Given the assumptions above, the continuous model of equation 2.2 may be written as shown in equation 2.3 which simplifies to the expression of equation 2.4 upon evaluation of the integral. Equation 2.4 shows that when the rate of growth of the nominal net income stream is identical to the inflation premium incorporated in the discount rate, the earnings-price ratio is equal to the real rate of interest regardless of the rate of inflation.

$$(2.3) \qquad V(t) = \int_{\delta=t}^{\infty} R_t e^{\pi(\delta-t)} e^{-(r+\pi)(\delta-t)} d\delta$$

$$(2.4) \qquad V(t) = \frac{R_t}{r}$$

One could hypothesize a scenario of increasing inflation and adaptive expectations of inflation in which the inflation premium included in the discount rate is less than the nominal rate of inflation. In this scenario the earnings-price ratio would be driven below the real rate of interest as persons bid the low cost of credit into land values, but as Tweeten (1981) suggests, this would not be a scenario of long-run equilibrium.

Though the equilibrium earnings-price ratio is always equal to the real rate of interest, the nominal value of the asset nonetheless increases over time as seen by evaluating the integral of equation 2.5. The result shown in equation 2.6 indicates that the value of the asset at some time in the future, say time t = n, is again equal to the quotient of the current net return and the real rate. Thus, the asset value has increased at rate π identical to the rate of increase in the current return.

$$(2.5) \qquad V(n) = \int_{\delta=n}^{\infty} R_n e^{\pi(\delta-n)} e^{-(r+\pi)(\delta-n)} d\delta$$

$$(2.6) \qquad V(n) = \frac{R_n}{r} = \frac{R_t e^{\pi(n-t)}}{r} = V(t)e^{\pi(n-t)}$$

Adams (1977) emphasizes that if the net return stream is expressed net of income taxes assessed at marginal rate T, then the discount rate must be specified on an after-tax basis as well. The basis of this argument is that the discount rate is to reflect the rate of return available on an alternative investment of comparable risk, and the return on any other investment alternative would also be taxed at rate T. Both the net income stream and the discount rate are specified on an after-tax basis in equation 2.7, and evaluation of the integral provides the result of equation 2.8.

$$(2.7) \qquad V(t) = \int_{\delta=t}^{\infty} R_t(1-T)e^{\pi(\delta-t)} e^{-(r+\pi)(1-T)(\delta-t)} d\delta$$

$$(2.8) \qquad V(t) = \frac{R_t(1-T)}{(r+\pi)(1-T)-\pi}$$

Equation 2.8 indicates that Adams' conclusion that income taxes are neutral with respect to the value of an asset with an infinite life does not hold in the case in which the nominal income stream is growing, even if that growth is entirely due to price inflation which is perfectly expected and fully incorporated in the discount rate. Indeed, an increase in the income tax rate increases the present value of the asset in the presence of inflationary growth of the net return stream.

The discrete model analogs to equations 2.3 through 2.8 are provided by equations 2.9 through 2.14, respectively. All conclusions drawn above for the continuous model apply directly to the discrete model without exception.

$$(2.9) \qquad V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1+\pi)^{i-t}}{(1+r+\pi)^{i-t}}$$

$$(2.10) \qquad V(t) = \frac{R_{t+1}}{r}$$

$$(2.11) \qquad V(n) = \sum_{i=n+1}^{\infty} \frac{R_n(1+\pi)^{i-n}}{(1+r+\pi)^{i-n}}$$

$$(2.12) \qquad V(n) = \frac{R_{n+1}}{r} = \frac{R_{t+1}(1+\pi)^{n-t}}{r} = V(t)(1+\pi)^{n-t}$$

$$(2.13) \quad V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1-T)(1+\pi)^{i-t}}{[1+(r+\pi)(1-T)]^{i-t}}$$

$$(2.14) \quad V(t) = \frac{R_{t+1}(1-T)}{(r+\pi)(1-T)-\pi}$$

Case Two: Real Growth of the Net Income Stream

Real growth of the net income stream accruing to agricultural land could arise from two sources. The first source is an increase in productivity providing an increase in output, bushels of corn per unit input, for example, which would provide an increase in net revenue given that there is no offsetting increase in unit costs of production or decrease in the price of output. Alternatively, the source of real growth could be an expansion in demand for agricultural products causing an increase in output price in excess of any increase occurring in the general price level.

Regardless of the source of real growth, assume that the rate of increase in net revenue is g percent. The rate of nominal price inflation π in the rest of the economy is assumed to be zero; therefore the discount rate d is equal to the real rate of interest r. Thus, the present value of the asset is as specified by equation 2.15 which is equivalent to the expression of 2.16.

$$(2.15) \quad V(t) = \int_{\delta=t}^{\infty} R_t e^{g(\delta-t)} e^{-r(\delta-t)} d\delta$$

$$(2.16) \quad V(t) = \frac{R_t}{r-g}$$

Comparing the result of equation 2.16 with that of equation 2.4, the present value of the asset is higher if the net income stream is growing in real terms. The earnings-value ratio is reduced to the difference between the real rate of interest and the real growth rate. Melichar (1979) documented the existence of real growth in net returns to farm production assets during much of the post-war period and used the result of 2.16 to explain land price behavior during that period.

As in the case of inflationary net return growth, the value of the asset increases over time at a rate equal to the rate of growth of the income stream, g, as shown by equations 2.17 and 2.18. In this instance, however, the asset owner realizes a real wealth gain whereas in the previous case the asset owner realizes a nominal wealth gain which merely keeps pace with the rate of price inflation π in the general economy.

$$(2.17)\quad V(n) = \int_{\delta=n}^{\infty} R_n e^{g(\delta-n)} e^{-r(\delta-n)} d\delta$$

$$(2.18)\quad V(n) = \frac{R_n}{r-g} = \frac{R_t e^{g(n-t)}}{r-g} = V(t)e^{g(n-t)}$$

Income taxation is added to the model in equations 2.19 and 2.20. Result 2.20 is directly analogous to that of result 2.8. Income taxes are not neutral with respect to the present value of an asset with an infinite life if the income stream accruing to that asset is growing in real terms. An increase in the income tax rate in the presence of real income growth increases the present value of the asset.

(2.19) $$V(t) = \int_{\delta=t}^{\infty} R_t(1-T)e^{g(\delta-t)}e^{-r(1-T)}d\delta$$

(2.20) $$V(t) = \frac{R_t(1-T)}{r(1-T)-g}$$

The results derived for the continuous version of the model are again robust when applied to the discrete version of the model. Equations 2.21 through 2.26 are the discrete model analogs to equations 2.15 through 2.20, respectively, and verify the conclusions derived above.

(2.21) $$V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1+g)^{i-t}}{(1+r)^{i-t}}$$

(2.22) $$V(t) = \frac{R_{t+1}}{r-g}$$

(2.23) $$V(n) = \sum_{i=n+1}^{\infty} \frac{R_n(1+g)^{i-n}}{(1+r)^{i-n}}$$

(2.24) $$V(n) = \frac{R_{n+1}}{r-g} = \frac{R_{t+1}(1+g)^{n-t}}{r-g} = V(t)(1+g)^{n-t}$$

(2.25) $$V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1-T)(1+g)^{i-t}}{[1+r(1-T)]^{i-t}}$$

(2.26) $$V(t) = \frac{R_{t+1}(1-T)}{r(1-T)-g}$$

Case Three: Real Growth and Inflationary Growth of the Net Income Stream

This case may be considered the general model from which Cases One and Two were derived by setting the rate of real growth to zero in the first and the rate of inflationary growth to zero in the latter. Allowing all symbols to retain the meanings assigned previously, the present value of an asset which is the source of a net return stream which is growing at a rate which exceeds the rate of price inflation π in the economy by an amount g is given by the equivalent expressions 2.27 and 2.28.

$$(2.27) \quad V(t) = \int_{\delta=t}^{\infty} R_t e^{(g+\pi)(\delta-t)} e^{-(r+\pi)(\delta-t)} d\delta$$

$$(2.28) \quad V(t) = \frac{R_t}{r-g}$$

A comparison of equations 2.4, 2.16, and 2.28 reveals that only that portion of the growth in nominal returns in excess of the rate of price inflation, the real growth component g, affects the present value of the asset. Regardless of the rate of price inflation, the earnings-price ratio is equal to the difference between the real rate of interest and the real rate of growth.

As shown in equations 2.29 and 2.30, however, the value of the asset in nominal terms does increase through time at the rate g plus π. Therefore, the owner's real wealth increases at rate g exactly as found in Case Two.

$$(2.29)\quad V(n) = \int_{\delta=n}^{\infty} R_n e^{(g+\pi)(\delta-n)} e^{-(r+\pi)(\delta-n)} d\delta$$

$$(2.30)\quad V(n) = \frac{R_n}{r-g} = \frac{R_t e^{(g+\pi)(n-t)}}{r-g} = V(t)e^{(g+\pi)(n-t)}$$

The model including income taxation is shown in equations 2.31 and 2.32. As in the previous two cases, the income tax is not neutral in the model with a growing net return stream. An increase in the marginal tax rate T increases the present value of the asset. Similarly, an increase in the rate of price inflation π increases the present value of the asset when taxes are included in the model.

$$(2.31)\quad V(t) = \int_{\delta=t}^{\infty} R_t(1-T)e^{(g+\pi)(\delta-t)} e^{-(r+\pi)(1-T)(\delta-t)} d\delta$$

$$(2.32)\quad V(t) = \frac{R_t(1-T)}{(r+\pi)(1-T)-(g+\pi)}$$

Equations 2.33 through 2.38 are the discrete model analogs to equations 2.27 through 2.32, respectively. All conclusions derived above for the continuous model hold for the discrete model as well.

$$(2.33)\quad V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1+g+\pi)^{i-t}}{(1+r+\pi)^{i-t}}$$

$$(2.34)\quad V(t) = \frac{R_{t+1}}{r-g}$$

$$(2.35) \quad V(n) = \sum_{i=n+1}^{\infty} \frac{R_n(1+g+\pi)^{i-n}}{(1+r+\pi)^{i-n}}$$

$$(2.36) \quad V(n) = \frac{R_{n+1}}{r-g} = \frac{R_{t+1}(1+g+\pi)^{n-t}}{r-g} = V(t)(1+g+\pi)^{n-t}$$

$$(2.37) \quad V(t) = \sum_{i=t+1}^{\infty} \frac{R_t(1-T)(1+g+\pi)^{i-t}}{[1+(r+\pi)(1-T)]^{i-t}}$$

$$(2.38) \quad V(t) = \frac{R_{t+1}(1-T)}{(r+\pi)(1-T)-(g+\pi)}$$

Harris (1979) uses an ad hoc specification, equation 2.39, of the model of equations 2.33 and 2.34 to discuss the effects of real growth and inflation on the present value of land. Although he adds the interesting feature of the weighted average cost of capital to the model (w_d and w_e are the respective proportions of debt and equity capital used in the purchase, and r_d and r_e are the discount rates for debt and equity capital), the assumptions under which his model is derived are not clear.

$$(2.39) \quad V(t) = \frac{R_t(1+g)}{w_d \cdot r_d + w_e \cdot r_e + \pi - g}$$

Apparently, Harris wishes to assume that a full inflation premium is incorporated into the discount rate but that the net income stream is not subject to inflationary growth. That is, the rate of real growth g of the income stream is equal to the negative of the rate of inflation π. Under that assumption, the model of equation 2.33 simplifies to the expression of 2.40 in which a full equity purchase has also been assumed to be consistent with the foregoing discussion.

$$(2.40) \quad V(t) = \frac{R_t}{r+\pi}$$

Though Harris' model specification appears to be inconsistent with the underlying logic of net present value determination, his conclusion that an increase in the rate of inflation would not necessarily lead to upward pressure on land values is correct under the assumption that g equals $-\pi$.

The Finite Holding Period

The assumption that the life of the asset is infinite was maintained throughout the analyses above, and in the case of farmland the assumption is plausible. The analyses were also developed under the assumption that the current buyer or owner of the asset had no plans to sell the asset in the future. If the current owner of the asset did plan to sell the asset at some future point in time, say at time t=n, the present value of the asset to the current owner would be the discounted stream of net revenues from the present time t to the future time n plus the discounted sale value of the asset.

The sale value of the asset at time n is equal to the discounted stream of net revenues from time n into the indefinite future as shown, for example, in equations 2.29 and 2.35. Equations 2.41 and 2.42 for the continuous model and 2.43 and 2.44 for the discrete model show that the length of the holding period does not affect the present value of an asset with an infinite life under the assumptions of real growth and perfectly anticipated inflation of Case Three. The same conclusion applies to the more restrictive cases in which either the rate of real growth or the rate of inflation is assumed to be zero.

$$(2.41) \quad V(t) = \int_{\delta=t}^{n} R_t e^{(g+\pi)(\delta-t)} e^{-(r+\pi)(\delta-t)} d\delta + V(n) e^{-(r+\pi)(n-t)}$$

$$(2.42) \quad V(t) = \int_{\delta=t}^{\infty} R_t e^{(g+\pi)(\delta-t)} e^{-(r+\pi)(\delta-t)} d\delta = \frac{R_t}{r-g}$$

$$(2.43) \quad V(t) = \sum_{i=t+1}^{n} \frac{R_t (1+g+\pi)^{i-t}}{(1+r+\pi)^{i-t}} + \frac{1}{(1+r+\pi)^n} \sum_{i=n+1}^{\infty} \frac{R_n (1+g+\pi)^{i-n}}{(1+r+\pi)^{i-n}}$$

$$(2.44) \quad V(t) = \sum_{i=t+1}^{\infty} \frac{R_t (1+g+\pi)^{i-t}}{(1+r+\pi)^{i-t}} = \frac{R_{t+1}}{r-g}$$

In the presence of a tax on capital gains assessed at the time of resale, however, the length of the holding period does have an effect on the present value of farmland. The logic upon which the model is built remains intact, but when extraordinary taxes of this sort are included in the analysis, the algebraic simplifications that allowed the model to be written in the form of equation 2.38 are not possible. Instead, the discounted values of all cash flows must be calculated directly. The model of Barry, Hopkin, and Baker (1983) recognizes the effect of a tax on capital gain, but their model does not recognize the difference between real and inflationary growth of the returns stream. The model provided in equation 2.45 is similar to that of Barry, Hopkin, and Baker with the exception that real and inflationary growth are recognized explicitly in a world including a tax on capital gain.

$$(2.45) \quad NPV(0) = \sum_{t=1}^{n} \frac{R_0(1-T)(1+g+\pi)^t}{X^t} + \frac{P^*_0\{(1+g+\pi)^n - T^*[(1+g+\pi)^n-1]\}}{X^n}$$

$$- \sum_{t=1}^{n} \frac{P_t + I_t(1-T)}{X^t} - \frac{D_n}{X^n} - DP_0$$

where $\quad X = 1+(r+\pi)(1-T)$

In equation 2.45 all symbols are as defined previously with the additions of the initial purchase price P^*, the capital gains tax rate T^*, periodic principal and interest payments P_t and I_t, debt D_n remaining at the end of the holding period, and the initial downpayment DP_o. The first four terms of equation 2.45 represent the value of the future stream of net returns after income tax, the value of the future sale net of capital gains tax, the value of the stream of debt service payments recognizing the income-tax deductibility of interest payments, and finally the remaining indebtedness at the time of resale, all discounted to present values. The income capitalization model of 2.45 is applied in the following section to an investment analysis of Iowa farmland.

An Application of the Income-Capitalization Model

Tables 2.1 and 2.2 summarize an analysis of the investment potential of Iowa farmland under a range of assumptions regarding the variables in the model of 2.45. Assumptions regarding net returns, growth rates, interest rates, and tax rates for the baseline run are shown in Table 2.1. Assume that each acre of land purchased will be used to raise one-half acre of corn and one-half acre of soybeans, a typical cropping pattern in Iowa. In addition assume that the investor will lease the land to a farm operator under the common share-lease arrangement in which the operator furnishes machinery and labor inputs, the owner furnishes the land and fixed improvements, most other variable costs of production are split equally between operator and owner, and the crop produced on the land is split equally following harvest between operator and owner.

The owner's share of the production costs and the crop are shown in the column in the upper right portion of Table 2.1. The owner can expect a net return in the first year of ownership of \$86.88 after all costs assuming a corn price of \$2.80 per bushel and a soybean price of \$5.02 per bushel. In this analysis the initial purchase price is assumed to be \$1250 per acre which is financed with a downpayment of 25 percent or \$312.50 and a 30-year loan requiring equal annual debt-service payments

Table 2.1. Baseline assumptions for a hypothetical investment in Iowa farmland

Production assumptions:[a]			
Yield per 1/2 acre (Bu.):		Owner share (Bu.):	Price:
Corn	70	35	$2.80
Soybeans	23	11.5	5.02
Production expenses:			
Seed, fertilizer, chemicals		$48.98	
Labor		--	
Fuel, oil, repairs		5.88	
Property taxes		14.00	
Total		$68.86	
Initial net return		$86.88	
Land purchase assumptions:			
Purchase price		$1250.00	
Downpayment		312.50	
Annual payment		99.45	(30-year loan at 10 percent interest)
Holding period		15 years	
Income tax rate		50%	
Capital gains tax rate		40%	of income tax rate
Inflation and growth projections:			
Inflation rate		4%	
Real growth rate		-2%	
Real rate of interest		6%	

[a]From Edwards (1985).

of \$99.45. The rate of interest charged on the mortgage is 10 percent consisting of the sum of the real rate of interest of six percent and the rate of inflation of four percent. The net return stream and the price of the land are assumed to grow at a rate of two percent annually indicating that in an environment of four percent inflation, real growth of the net return stream and the value of the land are -2 percent. Net returns are taxed at a 50 percent rate. At the end of a 15-year holding period, the land is sold, capital gains taxes assessed at the rate of 40 percent of the ordinary income tax rate are paid on the nominal appreciation of the value of the land, and the outstanding indebtedness against the land is repaid.

The criterion for assessing the profitability of the investment opportunity is the net present value calculated using equation 2.45. A positive net present value indicates that the rate of return of the investment exceeds that found in alternative investments represented by the discount rate in equation 2.45; conversely, a negative net present value suggests that alternative investments will provide a higher rate of return.

The five panels of Table 2.2 provide sensitivity analyses of the net present value of an investment in Iowa farmland given one-at-a-time changes of several of the parameter values of Table 2.1. In each panel, a range of purchase prices ranging from \$1000 per acre to \$2000 per acre is considered. Panel A indicates that as the price of corn declines from the baseline value of \$2.80 causing a reduction in net returns, the feasible (in the sense of providing a return which is favorable relative

Table 2.2. Sensitivity analysis of a hypothetical investment in Iowa farmland

Panel A. Sensitivity to a change in the price of corn

Corn price ($/bu)	Land purchase price ($/acre) 1000	1250	1500	1750	2000
	Net Present Value				
2.00	-33	-129	-226	-322	-419
2.25	20	-77	-173	-270	-366
2.50	72	-25	-121	-217	-314
2.65	103	7	-90	-186	-282
2.80	135	38	-58	-155	-251

Panel B. Sensitivity to a change in the inflation rate

Inflation rate	Land purchase price ($/acre) 1000	1250	1500	1750	2000
	Net Present Value				
0.00	-45	-168	-291	-414	-537
0.03	85	-19	-124	-228	-332
0.04	135	38	-58	-155	-251
0.05	189	101	13	-75	-164
0.06	246	167	88	9	-69

Panel C. Sensitivity to a change in the income tax rate

Income tax rate	Land purchase price ($/acre) 1000	1250	1500	1750	2000
	Net Present Value				
0.00	73	-96	-266	-435	-605
0.10	84	-75	-233	-392	-550
0.20	96	-50	-196	-343	-489
0.30	108	-24	-155	-287	-419
0.40	121	6	-109	-225	-340
0.50	135	38	-58	-155	-251

Table 2.2. Continued

Panel D. Sensitivity to a change in the real rate of interest

Real rate of interest	Land purchase price ($/acre)				
	1000	1250	1500	1750	2000
	Net Present Value				
0.04	269	196	123	50	-22
0.05	199	114	29	-56	-141
0.06	135	38	-58	-155	-251
0.07	75	-32	-139	-246	-353
0.08	19	-98	-215	-332	-449

Panel E. Sensitivity to a change in the real rate of growth

Real rate of growth	Land purchase price ($/acre)				
	1000	1250	1500	1750	2000
	Net Present Value				
-0.04	-68	-198	-328	-457	-587
-0.02	135	38	-58	-155	-251
-0.01	256	180	104	28	-48
0.00	393	341	288	235	183
0.01	548	522	496	470	444

to that available from alternative investments) purchase price declines. An increase in the real rate of growth of the net return stream over time (Panel B) makes higher purchase prices feasible in a fashion similar to that of an increase in the price of corn. An increase in the inflation rate (Panel C) results in a higher feasible purchase price due to the favorable tax treatment of capital gains. Similarly, the higher-tax bracket investor (Panel D) can afford a higher initial purchase price.

Of particular interest to the development of the models which follow in subsequent chapters is the effect of a change in the real rate of interest on the feasible purchase price of farmland (Panel E). In this income-capitalization model of farmland value, an increase in the real rate of interest causes a decrease in the feasible purchase price. The definition of the real rate of interest and a discussion of the determinants of the real rate are the topics of the following chapter.

CHAPTER THREE: THE REAL RATE OF INTEREST

In the foregoing analyses, the current value of farmland was expressed as the discounted stream of future net rents accruing to the land owner. The rate of discount was represented as the sum of the real rate of interest and the rate of price inflation. The focus of this chapter is the first component of the discount rate, the real rate of interest.

The objectives of the first section of the chapter are to develop the conceptual definition of the real rate of interest and to establish the relationship between the real rate of interest, the monetary or nominal rate of interest, and the rate of inflation. The objective of the latter sections of the chapter is to describe models which provide a theoretical basis for the hypothesis that monetary policy can affect land values by changing the real rate of interest. With the conclusion of this chapter, the stage is set for the presentation of the more detailed conceptual model of Chapter Four, a model which provides for the analysis of the effects of fiscal policy as well as monetary policy on the real rate of interest and the value of farmland.

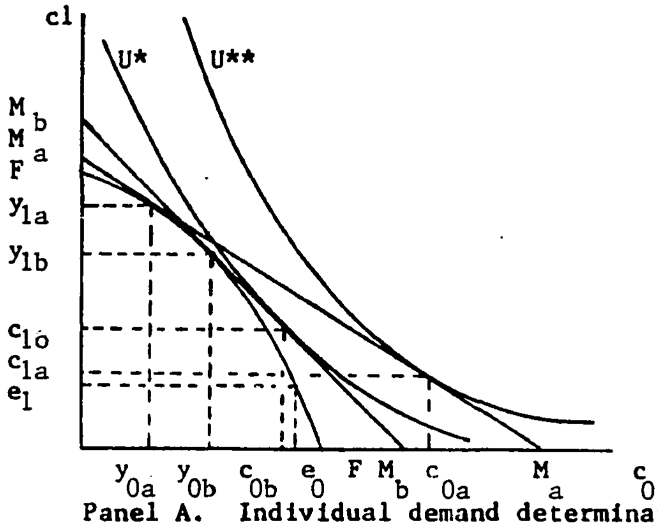
The Definition and Determination of the Real Rate of Interest

The principle reference for the following discussion is Hirschleifer (1970) supplemented from Fisher (1930), Copeland and Weston (1983), and Van Horne (1984). Hirschleifer (p. 135) defines the real rate of interest as "the rate of discount on future real claims c_1 in terms of current real claims c_0, or the 'premium' on current real claims in terms of future ones." Simply stated, the real rate of interest represents the number of units of consumption in the next time period which are sacrificed to gain another unit of consumption in the current time period or rather the price of current consumption measured in terms of future consumption.

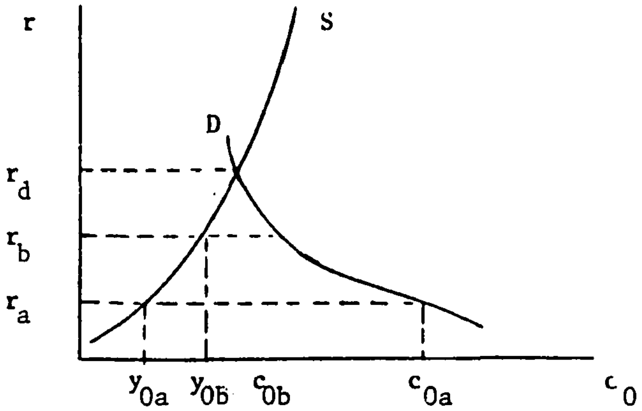
The three panels of Figure 3.1 show that the real rate of interest is determined by consumer time preferences in consumption, time productive opportunities, and time endowments. In this two-period model, the individual consumer of panel A has preferences for consumption in the current period 0 and the next period 1 as displayed by indifference curves U* and U**, a partial representation of the consumer's utility function $U(c_0,c_1)$. The individual is endowed with e_0 and e_1 units of the single consumptive commodity c in periods 0 and 1, respectively. Available technology allows the individual to make intertemporal conversions of the endowed commodities along the investment frontier FF. Given the market real rate of interest r, the consumer is faced with the budget constraint depicted as the market line MM and specified in equation 3.1

$$(3.1) \qquad W = y_0 + \frac{y_1}{1+r} \geq c_0 + \frac{c_1}{1+r}$$

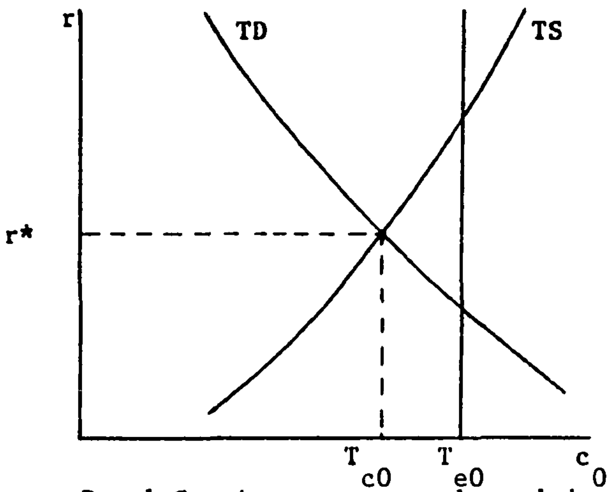
Two utility maximizing solutions are shown in Panel A, one for real rate r_a and one for real rate r_b. If the real rate is r_a, the optimal solution to the consumer's intertemporal, utility-maximization problem is



Panel A. Individual demand determination.



Panel B. Individual supply and demand for c_0.



Panel C. Aggregate supply and demand for c_0 and equilibrium real rate determination.

Figure 3.1. Determination of the real rate of interest

attained when the consumer first adopts a wealth maximizing investment strategy resulting in an individual supply of y_{0_a} and y_{1_a} units of commodity c in periods 0 and 1, respectively. The consumer then borrows along market line M_aM_a providing for the consumption of c_{0_a} and c_{1_a} units of c in the two consecutive time periods.

When the real rate rises to r_b, the optimal solution consists of a reduced level of investment along FF and a reduced level of borrowing along M_bM_b. Regardless of the position of the market line, the analysis above provides an illustration of the separation theorem whereby the consumer makes two independent optimizing decisions, the first being the wealth maximizing investment decision along FF and the second being the utility-maximizing, intertemporal consumption decision along one of the lines MM.

Panel B depicts the individual's supply and demand schedules for consumption in the current time period, c_0, as a function of the real rate of interest r. The position of the supply schedule S and the demand schedule D are determined by the locus of productive possibilities FF, preferences given by $U(c_0, c_1)$, and the initial endowments in time at point (e_0, e_1). As the real rate rises from r_a through r_b, the individual invests less of the period 0 endowment and simultaneously reduces period 0 consumption. At real rate r_d, the individual remains an investor but declines to either borrow or lend along the prevailing market line.

In the foregoing discussion of panels A and B of Figure 3.1, the individual was assumed to accept the real rate as determined in some market; the individual's actions did not affect the real rate. Panel C is a representation of the market determination of the equilibrium real rate of interest. Curves TD and TS represent the aggregation of the supply and demand schedules for current period consumption of all individual consumers as represented in panel B. At the equilibrium real rate r* total current period consumption in the economy, T_{c_o}, is less than the economy-wide current period endowment, T_{e_0}. That is, net investment occurs in the economy.

Four implications of the discussion above are notable:

1) An increase in the real rate of interest could be caused by an increase in time preference in consumption or an increase in productive opportunities.

2) Stagnant economies can be divided into two groups, those with a strong time preference in consumption characterized by a high real rate, and those with few productive opportunities characterized by a low real rate.

3) The real rate does not have to be positive. Suppose there were few productive opportunities and that storage losses did occur. Then the slope of the linear investment frontier would be $(1+r) < 1$ which implies $r < 0$.

4) Typically the real rate can be expected to be positive due to the plausible existence of time preference in consumption and the existence of many productive opportunities which are exhausted slowly and expanded constantly with the development of new technology.

Having defined the real rate r as the cost of current consumption in terms of future consumption and having considered the factors which determine the real rate, money m is now added to the model so that the consumer's wealth is determined by the sum of the individual's holdings of m and c. Directly analogous to the definition of the real rate of interest r, the monetary rate of interest r_m is defined as the rate of discount applied to future money holdings in terms of current money holdings. These definitions of the real rate and the monetary or nominal rate are stated algebraically in equations 3.2 and 3.3, and the price levels in periods 0 and 1 are defined in equations 3.4 and 3.5, respectively.

$$\frac{dc_0}{dc_1} = \frac{-1}{1+r} \tag{3.2}$$

$$\frac{dm_0}{dm_1} = \frac{-1}{1+r_m} \tag{3.3}$$

$$\frac{dm_0}{dc_0} = P_0 \tag{3.4}$$

$$\frac{dm_1}{dc_1} = P_1 \tag{3.5}$$

Equations 3.6 and 3.7 show the relationship between the monetary rate, the real rate, and the price levels in the two time periods. Equating the price ratio P_1/P_0 to $1+\pi$ where π is the proportionate change in the price level or the rate of inflation, the monetary rate can be shown (equations 3.8 and 3.9) to be the sum of the inflation rate, the real rate, and a cross-product term which approaches zero as the period length shortens and which is typically assumed to be of negligible magnitude.

$$(3.6) \quad 1+r_m = \frac{P_1}{P_0}(1+r)$$

$$(3.7) \quad 1+r_m = (1+\pi)(1+r)$$

$$(3.8) \quad r_m = \pi + r + \pi r$$

$$(3.9) \quad r_m \cong \pi + r$$

Equation 3.9 holds in the case of perfect foresight in which the rate of inflation π in the following period is known with certainty. If the future rate of inflation is not known with certainty, then the nominal rate of interest may be expressed as the sum of the expected rate of inflation and the real rate of interest or the sum of the actual rate of inflation π_a and an estimate of the real rate of interest which Hirschleifer calls the commodity rate, r_c (equation 3.10).

$$(3.10) \quad r_m = \pi_a + r_c$$

Assume, for example, that the real rate is .05 and that the expected rate of price inflation is .04 providing for a nominal rate of .09 at the beginning of the period. Observation at the end of the period, however, reveals that the actual level of price inflation which occurred during the period was .08 providing an estimate of the real rate, the commodity rate r_c, of .01. Obviously, if individuals do not accurately anticipate higher rates of inflation, the estimated real rate is lower than the actual real rate. In the long-run, however, after expectations have fully adjusted to the higher rate of inflation, this analysis suggests that the commodity rate and the real rate would be equal and that the nominal rate would adjust fully to an increase in the rate of inflation.

The theory of the impact of a change in the rate of inflation on the real rate of interest is not limited to an analysis of the effect of a lag in the adjustment of expectations of inflation. Indeed, the models to be reviewed in the following section of this chapter provide the theoretical basis for a change in the real rate of interest in response to a fully anticipated change in the rate of inflation.

The basis for the models described in the following section of this chapter is that an increase in inflation caused by an increase in the rate of monetary expansion reduces the rate of return on real money balances. In response to the inflation-induced change in the relative rate of return from the two assets, money and real capital, available for inclusion in the investor's wealth portfolio, the asset holder shifts wealth from real balances to real capital. As real capital accumulates, declining marginal productivity ensures that the rate of return on the larger capital stock and the real rate of interest fall. In terms of

Figure 3.1, Panel A, the optimal investment point (y_o, y_1) moves northwest along curve FF.

Money in the scenario described above is not superneutral because the magnitude of real variables is affected by an increase in the rate of monetary expansion. The objective of the following section is to develop the theoretical framework for the simple economy in which money is not superneutral. The ultimate objective in the development of the sequence of models which follow is the inclusion of farmland as an alternative asset in the wealth portfolios of asset holders.

Monetary Policy, the Real Rate, and Land Value

In this section, two well-known models selected from the literature are reviewed. The first of these is a model which corresponds closely to the discussion of the previous section, a model in which only money exists in addition to a single consumptive-capital good. The second model is a variant of the first in which money is excluded from the model, but land is added. At the conclusion of this chapter, the task which will remain for Chapter Four is the development of a similar model which is also built around the concept of portfolio-balancing behavior but which includes an expanded set of assets, real capital, real land, and government debt consisting of bonds as well as money.

The Sidrauski money-capital model

The Sidrauski (1967) model incorporates a second asset, government noninterest-bearing debt or money, into a Solow-type, single-asset model of economic growth. Sidrauski argues that leaving money out of the model is a rational way to view the world if money is neutral, a condition that depends on flexible prices and the exclusion of wealth as an argument in the consumption or saving functions. When money is added to the model as an alternative means of holding wealth, money is neutral but not super-neutral. That is, a one-time increase in the money stock causes a proportionate increase in the price level without affecting the value of real variables in the model. An increase in the rate of monetary expansion, however, does affect the value of real variables in the model. In particular, the real rate of interest declines.

The Sidrauski model is a "descriptive" model which specifies aggregate savings S as some fixed percentage s of disposable income Y_d (3.11). The term descriptive distinguishes the model from a model which would specify savings from some optimizing behavior. Disposable income is the sum of aggregate output Y, transfers V from the monetary authority to consumers, less the depreciation in consumer wealth during the period (3.12).

$$(3.11) \quad S = sY_d$$

$$(3.12) \quad Y_d = Y + V - D$$

The aggregate production function specifies that two inputs, real capital K and labor N, are used to produce an aggregate output which is physically indistinguishable from the real capital input (3.13).

(3.13) $Y = Y(K, N)$

Transfers from the monetary authority are represented by an increase in real money balances M/P where P is the price of real capital, the numeraire, and the dot over the M indicates the time derivative, a notation which will be used throughout the following discussion (3.14).

(3.14) $V = \frac{\dot{M}}{P} = \frac{\theta M}{P}$

where: $\theta = \frac{\dot{M}}{M}$

The flow of disposable income, however, is decreased by depreciation of the real capital stock at rate u and the loss in value of real money balances which occurs at the rate of inflation (3.15 and 3.16).

(3.15) $D = uK + \frac{\pi M}{P}$

(3.16) $Y_d = Y(K, N) - uK + (\theta - \pi) \frac{M}{P}$

The stock of wealth W at the beginning of the period is equal to the sum of the real capital stock and real money balances (3.17). The only means of increasing wealth is through saving from the flow of disposable income; thus, savings are equal to the time derivative of wealth (3.18). Equation 3.19 is derived by substituting 3.11 and 3.16 into 3.18 and rearranging.

$$(3.17)\quad W = K + \frac{M}{P}$$

$$(3.18)\quad S = \dot{W} = \dot{K} + (\theta - \pi)\frac{M}{P}$$

$$(3.19)\quad \dot{K} = s[Y(K, N) - uK] - (1-s)(\theta - \pi)\frac{M}{P}$$

Assuming that the aggregate production function is characterized by constant returns to scale and defining k as the per capita capital stock (ratio of K to N), y(k) as the aggregate production function written in intensive form (ratio of Y to N), m as per capita real money balances (ratio of M/P to N), and g as the rate of growth of the labor force, the time rate of change of the capital stock can be expessed as the time rate of change of the capital-labor ratio as shown in equation 3.20.

$$(3.20)\quad \dot{k} = s[y(k) - uk] - (1-s)(\theta - \pi)m - gk$$

Equation 3.20 is a description of the division of disposable income between the competing ends of consumption and wealth accumulation. The equation states that growth in the capital-labor ratio is equal to savings from net per capita output less that portion of net per capita money transfers used to increase per capita consumption and less that portion of additions to the capital stock required to maintain the capital-labor ratio as the labor force grows at rate g.

To complete the model, a specification of the division of the consumer-investors' wealth between alternative assets must be provided.

Portfolio-balancing behavior in the model is based on the relative rates of return available from the two assets in the model, real capital and money. This logic is identical to that of Tobin's static model in which the simultaneous determination of the demand for individual assets based on the vector of rates of return on all available assets is emphasized (Tobin, 1969; Brainard and Tobin, 1968).

Sidrauski suggests that the per capita money-capital ratio is a decreasing function of the nominal rate of interest i where i is equal to the difference between the rate of return on real capital and the rate of return on real money balances (3.21). An alternative money-demand function which facilitates the analysis of the stability characteristics of the model without making qualitative changes in the model's results is employed in this presentation (3.22).

(3.21) $\frac{m}{k} = L(i) = L[(y'(k)-u) - (-\pi)]; \quad L'(i) < 0$

(3.22) $i = \phi(k, m); \quad \phi_K > 0, \ \phi_m < 0$

$$\therefore \phi(k, m) = y'(k) - u + \pi$$

Equation 3.20 is one of the two differential equations required to effect an analysis of the dynamic properties of the model. The second equation (3.24) is derived by substituting the money market equilibrium condition (3.22) into the time derivative of per capita real money balances (3.23).

$$(3.23)\quad \dot{m} = m \cdot (\theta - \pi - g)$$

$$(3.24)\quad \dot{m} = m \cdot [\theta - \phi(k, m) + y'(k) - u - gk]$$

At steady state the capital-labor ratio and the real balances-labor ratio are unchanging. Setting 3.23 equal to zero, the steady state rate of inflation is equal to the difference between the rates of monetary expansion and labor force growth (3.25). Substituting 3.25 into 3.20, setting 3.20 equal to zero, and rearranging, the relation between the steady state values of per capita balances and real capital is found (3.26).

$$(3.25)\quad \pi^* = \theta - g$$

$$(3.26)\quad m^* = \frac{s[y(k^*) - uk^*] - gk^*}{(1-s)g}$$

In summary, the two equations describing the dynamic behavior of the model are equations 3.24 and 3.26. Equation 3.24 derived from investor portfolio behavior specifies the per capita balances investors are willing to hold, and equation 3.26 describes the level of per capita balances required to maintain steady state for each steady state capital-labor ratio. From these two equations, issues regarding the existence and stability of the steady state can be explored, and the effect of a change in model parameters--a change in the rate of monetary expansion is of particular interest--on the steady state values of the endogenous variables can be analyzed.

The dynamic properties of the model are depicted graphically in Figure 3.2. Curve OZ is the locus of combinations of m and k along which m is constant as given by equation 3.24. The curve passes through the origin and is upward sloping as shown by the derivative of equation 3.27. The direction of motion in m on either side of locus OZ is determined from equation 3.28.

$$(3.27)\quad \left.\frac{dm}{dk}\right|_{\dot{m}=0} = \frac{y''(k)-\phi_k}{\phi_m} > 0$$

$$(3.28)\quad \left.\frac{d\dot{m}}{dk}\right|_{dm=0} = \left[y''(k)-\phi_k\right] m < 0$$

The second curve of Figure 3.2, curve OX, is the locus of steady-state combinations of m and k as determined in equation 3.26. The shape of OX is determined in equation 3.29, the first derivative of 3.26, which is positive for small values of k and negative for large values of k under the assumption of a declining marginal product with respect to k. The second derivative of 3.26 is negative assuring that OX is concave downward. The direction of motion of k on either side of locus OX is determined from derivative 3.30.

$$(3.29)\quad \left.\frac{dm}{dk}\right|_{\dot{m}=\dot{k}=0} = \frac{s\left[y'(k^*)-u\right]-g}{(1-s)g} \gtrless 0 \quad \text{for } k \begin{matrix}\text{small}\\ \text{large}\end{matrix}$$

$$(3.30)\quad \left.\frac{d\dot{k}}{dm}\right|_{dk=0} = -(1-s)g < 0$$

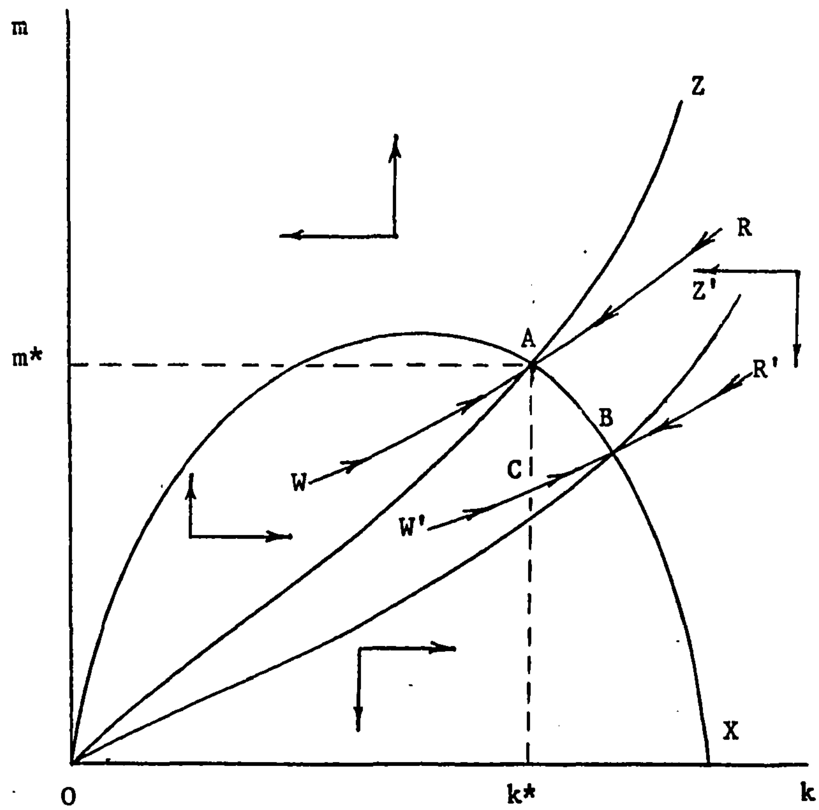


Figure 3.2. Phase diagram for the Sidrauski model

Figure 3.2 is a diagram of the dynamic behavior of a system which is saddle-point unstable. Any initial combination of m and k lying on saddlepath WR will move over time to steady state A. Other initial combinations of m and k move away from A as time passes. Having established the existence of a steady state and the dynamic behavior of the model, a consideration of the effects of an increase in the rate of monetary expansion is appropriate.

The derivative of equation 3.24 with respect to the rate of monetary expansion θ is positive. Point A represents a point where per capita real balances m are constant over time, but after the increase in θ, point A must represent a point at which m is growing. The laws of motion of the system dictate that the new locus of constant m lies below point A. Therefore the increase in θ causes a downward shift of locus OZ to OZ'.

Inspection of equation 3.26 indicates that locus OX is not affected by an increase in θ. Therefore the new steady state is at point B, and the laws of motion for the region surrounding point B are identical to those which prevailed around steady state A. The new saddlepath is W'R'.

Of particular relevance to this study is the fact that an increase in the rate of money growth results in an increase in the per capita capital stock and a decline in per capita real balances at steady state. The intuitive explanation for this important result follows the logic of Tobin's model and is called the Tobin effect. Investors perceive an increase in the rate of inflation as a result of the increase in the rate of monetary expansion. The higher rate of inflation translates directly into a reduced rate of return on real balances. Therefore investors economize on real balances choosing to hold a larger portion of their aggregate wealth in the form of real capital. As capital accumulates, declining marginal physical productivity ensures that the rate of return on real capital declines, and equilibrium is eventually reestablished in the investors' portfolios.

The second effect of the increase in θ evident in Figure 3.2 is the "impact effect". At the instant of the increase in θ, the only free variable which can assume a new value to accommodate the jump from steady state A to the new saddle path W'R' at point C is the price level P. A discrete jump in P places the system at point C. Then both m and k increase along the new saddlepath until the new steady state B is reached.

These comparative steady state results are especially interesting in the context of the objective of this dissertation if one were to consider farmland to be a form of real capital. The Sidrauski model suggests that an increase in the rate of monetary expansion would increase the demand for farmland as investors switched out of money and into land. Increased demand would result in a higher price, especially if farmland were in fixed supply. Nichols (1970) developed a model almost identical to that of Sidrauski to consider the two real-asset case when one of the assets is in fixed supply as Nichols assumed was the case for farmland. A review of the Nichols model follows.

The Nichols capital-land model

The Nichols (1970) model is described in equations 3.31 through 3.49 in which the notation of the original Nichols paper has been modified to correspond directly with that used in the presentation of the Sidrauski model in the previous section. As in the Sidrauski model, saving is specified as a constant percentage of disposable income (equations 3.31 and 3.32). The first characteristic distinguishing the Nichols model from the Sidrauski model appears in the specification of the aggregate production function of equation 3.33.

$$(3.31) \quad S = sY_d$$

$$(3.32) \quad Y_d = Y + V - D$$

$$(3.33) \quad Y = Y(K, N, L)$$

where:

$$N = N_0 e^{gt}$$

$$L = L_0 e^{gt}$$

$$\frac{N}{L} = \frac{N_0}{L_0} = B$$

Land L is included as a factor of production in the Nichols model, and technological progress is assumed to augment the productivity of the fixed stock of land L_o so that the effective land input grows at rate g. As in the Sidrauski model, the labor force N grows at rate g as well.

Capital gains on land holdings (3.34) rather than net transfers from the monetary authority contribute to consumer disposable income. The capital good K is again the numeraire, and P_L is the price of land in terms of goods. Because money is not included in this model, the only source of wealth deterioration reducing disposable income is depreciation of the capital stock at rate u.

$$(3.34) \quad V = \dot{P}_L L_0$$

$$(3.35) \quad D = uK$$

$$(3.36) \quad Y_d = Y(K, N, L) - uK + \dot{P}_L L_0$$

Savings contribute to total consumer wealth which is held as capital or as land (3.37 and 3.38). Equation 3.39 describes the division of consumer income between consumption and wealth accumulation. Assuming constant returns to scale in production, 3.39 is written in intensive or per capita form in 3.40 where ℓ is the ratio of the fixed stock of land in terms of goods to labor ($P_L \cdot L_o/N$).

$$(3.37) \quad W = K + P_L L_0$$

$$(3.38) \quad S = \dot{W} = \dot{K} + \dot{P}_L L_0$$

$$(3.39)\quad \dot{K} = s[Y(K,\ N,\ L) - uK] - (1-s)\dot{P}_L L_0$$

$$(3.40)\quad \dot{k} = s[y(k) - uk] - (1-s)\,\frac{\dot{P}_L}{P_L}\ell - gk$$

Equation 3.41 specifies the portfolio behavior of the wealth holders in the economy, and is directly analogous to equation 3.21 of the Sidrauski model. Note that the rate of depreciation u is assumed to be zero in 3.41 and the remainder of the model to simplify the presentation. According to 3.41, the profit maximizing investor will allocate wealth between the two available assets, land and capital, so that the rates of return on the two assets are equal. The rate of return on capital is its marginal product, and the rate of return on land includes a capital gain in addition to its marginal product. The description of portfolio behavior of 3.41 is written in intensive form in 3.42.

$$(3.41)\quad Y_K = \frac{Y_{L_o}}{P_L} + \frac{\dot{P}_L}{P_L}$$

$$(3.42)\quad y'(k) = \frac{y(k)-ky'(k)}{\ell} + \frac{\dot{P}_L}{P_L}$$

Equation 3.44, derived by substituting the steady state condition of 3.43 into 3.42 and rearranging, is the first of the two expressions which describe the dynamic behavior of the model. The second expression, equation 3.45, is found by setting equation 3.40 equal to zero, substituting steady state condition 3.43 and rearranging. Equation 3.44 describes per capita land holdings that investors are willing to hold, and equation 3.45 provides the locus of steady state combinations of per capita land and capital holdings.

$$(3.43) \quad \dot{\ell} = \ell \left(\frac{\dot{P}_L}{P_L} - g\right) = 0$$

where: $$\ell = \frac{P_L \cdot L_0}{N}$$

$$\frac{\dot{\ell}}{\ell} = \frac{\dot{P}_L}{P_L} - n$$

$$(3.44) \quad \ell \Big|_{\dot{\ell}=0} = \frac{y(k) - ky'(k)}{y'(k)-g}$$

$$(3.45) \quad \ell \Big|_{\dot{k}=\dot{\ell}=0} = \frac{s \cdot y(k) - gk}{(1-s)g}$$

The phase diagram showing the dynamic behavior of this simple economy is developed from equations 3.44 and 3.45 and is shown in Figure 3.3. Curve OJ, the locus of constant land-labor ratio from equation 3.44, is drawn with an upward slope as indicated by the derivative of 3.46. The sign of 3.46 is determined by the sign of the expression in square brackets in the numerator, an expression which is positive when $y'(k)-g$ is positive, and $y'(k)-g$ must be positive for ℓ to be positive in

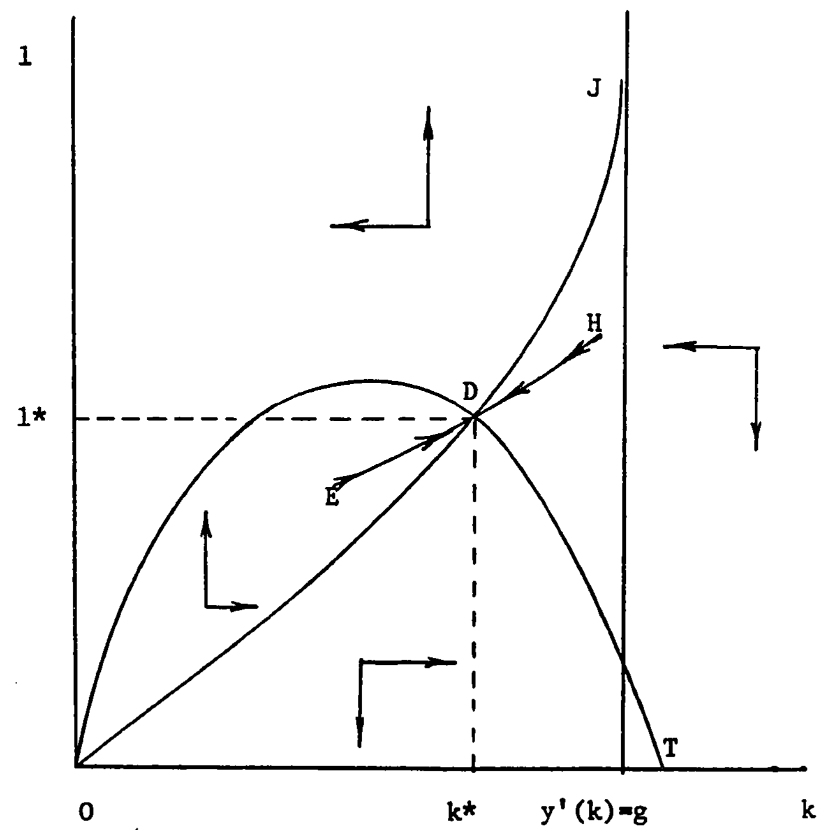


Figure 3.3. Phase diagram for the Nichols model

3.44. The direction of motion of the land-labor ratio on either side of curve OJ is determined from derivative 3.47.

$$(3.46)\quad \left.\frac{d\ell}{dk}\right|_{\dot{\ell}=0} = \frac{-y''(k)[y(k) - gk]}{[y'(k) - g]^2} > 0$$

$$(3.47)\quad \left.\frac{d\dot{\ell}}{dk}\right|_{\bar{\ell}} = (\ell+k)y''(k) < 0$$

Note that the OJ locus approaches the line y'(k)=g asymptotically. This is a result of the portfolio behavior rule specified in 3.41. As capital accumulates and its marginal product declines towards g, investors shift assets from capital to land driving the price of land higher lowering the return on the land investment.

The second curve of Figure 3.3, curve OT, is the locus of combinations of l and k satisfying equation 3.45. The first derivative of 3.45 shown in equation 3.48 is positive for small values of k and negative for large values of k due to declining marginal physical productivity. The second derivative of 3.45 is negative ensuring that locus OT is concave downward. The direction of motion of k on either side of OT is determined from the derivative in 3.49.

$$(3.48)\quad \left.\frac{d\ell}{dk}\right|_{\dot{\ell}=\dot{k}=0} = \frac{s\cdot y'(k)-g}{(1-s)g} \gtrless 0 \text{ for } k \begin{matrix}\text{small}\\ \\ \text{large}\end{matrix}$$

$$(3.49)\quad \left.\frac{d\dot{k}}{d\ell}\right|_{\bar{k}} = -(1-s)\,\frac{\dot{P}_L}{P_L} < 0$$

The completed phase diagram of Figure 3.3 is nearly identical in appearance to that constructed for the Sidrauski model. The model economy is saddle-point unstable with an upward sloping saddle path EH passing through saddle point D.

A hypothesis drawn from the Sidrauski and Nichols models

The Sidrauski and Nichols models taken together provide the basis for conceptualizing the effect of the actions of the monetary authority on land value in a model which includes three assets, real capital, land, and money, as alternative means of holding wealth. From the Sidrauski model one could hypothesize that an increase in the rate of expansion of the money supply would cause investors to reduce their holdings of real balances and to attempt to increase the proportion of real capital and land in their portfolios. As capital accumulates, however, its marginal product declines causing an additional increase in demand for land, a result derived from the Nichols model. If the supply of land is inelastic or fixed as Nichols assumed, the price of land would rise lowering the rate of return on the land investment reestablishing equilibrium in investors' portfolios. The equilibrium is characterized by reduced holdings of real balances, a larger aggregate capital stock, and a higher land price.

A complete analysis of the hypothesis discussed above requires the development of a model which fully incorporates all three assets. In addition, the inclusion of government interest-bearing debt or bonds in addition to government noninterest-bearing debt or money in the model would provide the basis for investigating the effects of both fiscal and monetary policy on the price of farmland. These are precisely the objectives of the following chapter.

CHAPTER FOUR: THE CONCEPTUAL LINKAGE BETWEEN MACROECONOMIC POLICY AND THE VALUE OF FARMLAND

This chapter builds upon the models of portfolio-balancing behavior developed by Sidrauski and Nichols and described in the previous chapter. Specifically, the first task to be undertaken is the inclusion of government interest-bearing debt or bonds as well as government noninterest-bearing debt or money in the wealth portfolio of a model very similar to the Sidrauski model. This step provides the basis for applying the model to an analysis of the effects of fiscal policy as well as those of monetary policy. The model of Foley and Sidrauski (1971) performs this function and is described briefly in the first section of the chapter.

The primary contribution of this chapter to the objective of this research begins with the second section in which land is added as the fourth alternative asset--in addition to money, government bonds, and real capital--to the wealth portfolio of the Foley and Sidrauski model. The full, four-asset model is then put to work in the analysis of the effects of changes in macroeconomic policy on the price of land in two experiments which conclude the description and discussion of the conceptual model.

The Foley and Sidrauski, Three-Asset Model

The model of Foley and Sidrauski is a dynamic model consisting of a two-sector economy in which an aggregate consumption good, C, and an aggregate investment good, I, are produced using inputs labor, N, and capital, K. The capital stock K is related to the produced investment good I by the expression $I = \dot{K}$, where the dot over the K indicates the first derivative with respect to time.

Two assets in addition to capital are available as alternative stores of wealth to investors in the economy. These assets are money M and bonds B issued by the government, the sum of which is equal to the total outstanding debt G of the government. Two constraints on the activities of the transactors in the economy are specified in the model. The first is the flow constraint on transactions in the consumption goods market in which the flow of commodities produced must be equal to the flow demand for consumables, a demand which is determined by the flow of disposable income. The second constraint is that imposed on the total value of the aggregate stock of consumer wealth at any point in time. Real wealth is constrained to the sum of the real value of the existing stock of government debt and the existing stock of the productive capital input.

The model which is developed in the following discussion is similar to the Foley-Sidrauski model with the exception that a fourth alternative store of real wealth, agricultural land, L, is added to the model. In addition to its role as a store of real wealth, land is also assumed to be a factor in the production of the aggregate consumable.

The Four-Asset, Conceptual Model

Assume that the aggregate consumable, C, is produced using the factors capital, K_c, labor, N_c, and land, L, according to the production function of equation 4.1. K_c and N_c are the portions of the total input supplies that are used in production of the consumable rather than the capital good. Moreover, following the convention adopted in the Nichols model presented in Chapter Three, technological change is assumed to augment the physical stock of both labor, N_o, and land, L_o, at the exponential rate n. Thus effective supplies of labor, N_c, and land, L, enter the production function 4.1. Similarly, the capital good I is produced from the remaining portion of the total available stocks of capital, K_I, and effective labor input, N_I, as provided by the production function 4.2 and the assumption of full employment of resources specified in equations 4.5 and 4.6.

(4.1) $C = F_c(K_c, N_c, L)$

where:

$$N_c = N_{0_c} e^{nt}$$
$$L = L_0 e^{nt}$$
$$\frac{N_c}{L} = \frac{N_{0_c}}{L_0} = B$$

(4.2) $I = F_I (K_I, N_I)$

where:

$$N_I = N_{0_I} e^{nt}$$

(4.3) $q_c = \frac{C}{N_c} = f_c(k_c)$

(4.4) $q_I = \frac{I}{N_I} = f_I\left(k_I\right)$

(4.5) $K_I + K_c = K$

(4.6) $N_I + N_c = N = N_0\ e^{nt}$

Both production processes 4.1 and 4.2 are assumed to be characterized by constant returns to scale which facilitates the writing of these functions in per capita or intensive form as done in equations 4.3 and 4.4. Under the assumptions of profit maximization under perfect competition with unrestricted factor mobility, the marginal value products of the respective factors of production will be identical in the two sectors as shown for the marginal value product of capital in equations 4.7 and 4.8 where P_k is the real price of capital in terms of the consumable, the numeraire.

(4.7) $\frac{\partial F_c}{\partial K_c} = f_c'\left(k_c\right) = MPP_k^c = R_k$

(4.8) $\frac{\partial F_I}{\partial K_I} \cdot P_k = f_I'\left(k_I\right) \cdot P_k = R_k$

Finally, the per capita output of the consumable and the capital good can be expressed as functions of the overall capital-labor ratio k and the real price of capital, P_k, as expressed in equations 4.9 and 4.10. Given a convex production possibilities frontier, an increase in

P_k will result in increased output of the capital good at the expense of production of the consumable. Assuming that the production of the consumable good is more capital intensive than that of the capital good, an increase in the overall capital-labor ratio k will result in increased production of the consumable at the expense of the production of the capital good. These two assumptions account for the signs of the partial derivatives shown in equations 4.9 and 4.10.

$$(4.9) \quad q_c = q_c\left(k,\ P_k\right);\ q_{c,\ 1} > 0,\ q_{c,\ 2} < 0$$

$$(4.10) \quad q_I = q_I\left(k,\ P_k\right);\ q_{I,\ 1} < 0,\ q_{I,\ 2} > 0$$

The real value of aggregate wealth at any point in time is equal to the real value of the outstanding stock of government debt, GP_m, the real capital stock, KP_k, and the real value of land, L_oP_L, a stock which is fixed in supply at L_o land units. Equation 4.12 is the per capita representation of equation 4.11. Although the total value of wealth is constrained at each instant of time by equation 4.11, wealth holders are free to alter the composition of the asset portfolio by allocating a greater or lesser proportion of total wealth to the four alternative assets in accordance with the total available supply of each asset.

$$(4.11) \quad W = \left(M + B\right) P_m + KP_k + L_0P_L$$

(4.12) $$w = gP_m + kP_k + \ell P_L$$

where: $$P_m = \frac{1}{P_c}$$

$$M+B = G$$

$$g = G/N$$

$$\ell = L_0/N$$

Equations 4.13 through 4.16 represent the equilibrium conditions in the market for each of the four assets, money, bonds, capital, and land. The left-hand side of each equilibrium condition represents the available real supply of the individual asset, and the right-hand side of each equation represents the total demand for the asset. These four equilibrium conditions together with the adding-up constraint of equation 4.12 form a simultaneous system of four independent equations describing the portfolio behavior of the wealth holders in the model economy.

(4.13) $$\frac{gP_m}{x} = L(w,\ y,\ \rho_m;\ \rho_b,\ \rho_k,\ \rho_L)$$

where: $$x = g/m$$

(4.14) $$\left(1 - \frac{1}{x}\right) gP_m = H(w,\ y,\ \rho_m,\ \rho_b,\ \rho_k,\ \rho_L)$$

(4.15) $$kP_k = J(w,\ \rho_m,\ \rho_b,\ \rho_k,\ \rho_L)$$

(4.16) $$\ell P_L = R(w,\ \rho_m,\ \rho_b,\ \rho_k,\ \rho_L)$$

The arguments of the individual asset demands, L, H, J, and R, include the total stock of real, per capita wealth, w, current income, y, which is equal to the total per capita output of the economy, and the rates of return, ρ_m, ρ_b, ρ_k, and ρ_L, on each of the four assets, money, bonds, capital, and land, respectively. Demand for each asset is assumed to increase with an increase in wealth; constraint 4.12, however, dictates that the partial derivatives of the four asset demands with respect to w must sum to one. Following Tobin's convention, the income variable y appears in only the demands for money and bonds. The demand for money is assumed to increase with an increase in y due to increased transactions demand. Conversely, the demand for bonds is assumed to decline with an increase in y as bonds, a more liquid asset than either capital or land, are sold to provide additional funds to meet greater transactions requirements. The demand for each asset is expected to increase with an increase in its own rate of return and to decrease with an increase in the rate of return on any of the alternative assets. The stock constraint, equation 4.12, dictates that the partial derivatives of the four asset demand functions with respect to any individual rate of return must sum to zero.

The rates of return on the four assets are specified in equations 4.17 to 4.20. The rate of return on money, ρ_m, is equal to the negative of the rate of inflation of the price of the consumption good. In the notation employed in this development of the model, P_m, the price of money, is the inverse of the price of the consumption good. The rate of increase of P_m is the rate of deflation of the price level, the negative of the rate of inflation, and therefore the rate of return on money. Similarly, the rate of return on government bonds, ρ_b, is equal to the nominal rate of interest i paid to the holders of bonds plus the increase in the value of bonds due to price deflation.

$$(4.17) \qquad \rho_m = \frac{\dot{P}_m}{P_m} = \pi_m$$

$$(4.18) \qquad \rho_b = i + \pi_m$$

$$(4.19) \qquad \rho_k = \frac{R_k}{P_k} + \frac{\dot{P}_k}{P_k} = r_k + \pi_k$$

$$(4.20) \qquad \rho_L = \frac{R_L}{P_L} + \frac{\dot{P}_L}{P_L} = r_L + \pi_L$$

The rates of return on the stocks of capital and land held in investor portfolios include capital gain from increase in the real price of the asset as well as the current return which accrues to the holder of the asset by virtue of the use of the asset as a factor in a productive activity. The current returns to capital and land are the marginal physical productivities of the assets, r_k and r_L, respectively. As shown in equations 4.19 and 4.20, the total return to either capital or land is the sum of the marginal physical productivity and the percentage gain in the real price of the asset.

The four independent equations describing investor behavior in the assets markets are capable of determining three asset rates of return or, alternatively, asset prices, in addition to total wealth. By substituting equations 4.12 and 4.17 through 4.20 into equations 4.13 through 4.16 and taking the price of money as exogenous, reduced form equations for the real price of capital, P_k, the real price of land, P_L, and the nominal rate of interest, i, can be derived. These reduced forms are provided in equations 4.21 through 4.23 along with the expected signs of the partial derivatives. The derivation of the asset-market, reduced-form equations is provided in Appendix A.

(4.21) $P_k = P_k(\overset{+}{g}, k, \ell, \overset{-}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$

(4.22) $P_L = P_L(\overset{+}{g}, k, \ell, \overset{-}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$

(4.23) $i = i(g, k, \ell, \overset{+}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$

Having specified the manner in which the stock of accumulated savings or wealth is allocated across alternative stores of wealth, the final step in the development of the model economy is the specification of the source of the flow of income and savings over time. Savings arise from disposable income y_d (equation 4.24) which differs from the total income of the economy y by the real value of net transfers ZP_m from the government plus real capital gains V on assets held in the investors' portfolios (equation 4.26). Real net transfers are the difference between the government's current real budget deficit $P_m d$ and real government expenditures e (equation 4.25).

$$(4.24) \quad y_d = y + P_m Z + V$$

$$(4.25) \quad P_m Z = P_m d - e$$

$$(4.26) \quad V = \pi_m g P_m + \pi_k k P_k + \pi_L \ell P_L$$

The second constraint on the activities of the transactors in the model economy is derived from the fact that the flow of disposable income y_d must be divided between savings, which add to the stock of wealth, and current consumption. The demand for current consumption is assumed to be a function of disposable income. That portion of disposable income which is not used to purchase goods for current consumption is saved. Three different savings rates are specified in the demand for current consumption in equation 4.27. The rate of saving (s_L) from capital gains on land is greater than that (s_k) from capital gains on capital which is in turn greater than that (s_y) from current income which includes net transfers from the government as well as capital gains on holdings of government debt. The basis for this size-ordering of savings rates is the assumption that capital gains on more liquid assets will be more readily converted to cash and spent than will capital gains on less liquid assets. This assumption is not important for the development of the remainder of the model and is included for the sake of completeness.

$$(4.27) \quad C_d = f(y_d)$$

$$= (1-s_y)\ [q_c(k,\ P_k) + P_k q_I(k,\ P_k) - e + (d+\pi_m g)\ P_m]$$

$$+ (1-s_k)\ \pi_k k P_k + (1-s_L)\ \pi_L \ell P_L$$

where: $0 < s_y < s_k < s_L < 1$

The total available supply of goods for current consumption C_s is the current output of consumables less that portion of current output which the government purchases (equation 4.28). The condition for equilibrium in the consumption goods market, equation 4.29, is the flow constraint in the model economy.

$$(4.28) \quad C_s = q_c(k,\ P_k) - e$$

$$(4.29) \quad q_c(k,\ P_k) - e = (1-s_y)\ [q_c(k,\ P_k) + P_k q_I(K,\ P_k) - e$$

$$+ (d+\pi_m g)P_m] + (1-s_k)\ \pi_k k P_k + (1-s_L)\ \pi_L \ell P_L$$

For the reader's convenience, the complete model is restated in equations 4.30 through 4.38. The first set of three equations in the model define the flow constraint of the consumption goods market, and the second set of three equations are the reduced form equations for P_k, P_L, and i as determined in the assets markets. The final set of three equations specify the rate at which the stock of each asset grows over time. Equation 4.36 indicates that the growth in the per capita capital stock is equal to per capita production of new capital less that growth in the capital stock required to maintain the existing ratio of capital to labor in the face of a growing labor force. Similarly, the growth in the per capita stock of government debt is equal to the current budget deficit less the growth in debt required to maintain the per capita debt stock as the labor force grows (equation 4.37). Finally, the per capita stock of land, which is in fixed supply, declines as the labor force grows (equation 4.38).

$$(4.30)\quad q_c - e = (1-s_y)\left[q_c + P_k q_I - e + (d+\pi_m g)P_m\right] + (1-s_k)\pi_k k P_k + (1-s_L)\pi_L \ell P_L$$

$$(4.31)\quad q_c = q_c(\overset{+}{k}, \overset{-}{P}_k)$$

$$(4.32)\quad q_I = q_I(\overset{-}{k}, \overset{+}{P}_k)$$

$$(4.33)\quad P_k = P_k(\overset{+}{g}, k, \ell, \overset{-}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$$

$$(4.34)\quad P_L = P_L(\overset{+}{g}, k, \ell, \overset{-}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$$

$$(4.35)\quad i = i(g, k, \ell, \overset{+}{x}, \overset{-}{\pi}_m, \pi_k, \pi_L)$$

$$(4.36)\quad \dot{k} = q_I - nk$$

$$(4.37)\quad \dot{g} = d - ng$$

$$(4.38)\quad \dot{\ell} = -n\ell$$

Having completed the tasks of adding two additional assets, government bonds and land, to the wealth portfolio of the Sidrauski model of Chapter Three, the full, four-asset model of equations 4.30 through 4.38 is now capable of analyzing questions of interest to this study. By studying the response of the endogenous variables in the model to adjustments in certain exogenous variables, the model economy is used to analyze two experimental, macroeconomic policies in the next two sections of the chapter. In the first experiment, the impact of an increase in the government's current deficit is considered. The focus of the second experiment is an increase in the target rate of inflation. Of particular interest are the effects of these adjustments in macroeconomic policy variables on the real prices of capital and land.

Experiment One:
An Increase in the Current Budget Deficit

In this experiment, assume that the monetary authority chooses to maintain a constant price level P_m* which in turn dictates that the rate of change in Pm is zero (equations 4.39 and 4.40). Furthermore, assume that fiscal policy is passive; that is, the current budget deficit is fixed at d* and the level of government expenditures is fixed at e* (equations 4.41 and 4.42). With these two assumptions in place, nine endogenous variables remain to be determined by the nine equations of the full model, 4.30 through 4.38.

(4.39) $P_m = P_m*$

(4.40) $\pi_m = 0$

(4.41) $e = e*$

(4.42) $d = d*$

Now assume that the government increases the value of the current fiscal deficit. An increase in d, given a constant scale of government expenditures, e, provides increased disposable income to consumers. Given that demand for consumption goods is determined as a percentage of disposable income, the result is excess demand in the consumption goods market. Typically, the price level, P_c (P_m), would rise (fall), to restore equilibrium to this market. In this experiment, however, the monetary authority has chosen to maintain a constant price level (equations 4.39 and 4.40) through adjustment of the monetary control variable, x, the ratio of the total stock of government debt to the portion of the debt which is monetized. If the price of money is held constant through the actions of the monetary authority, then the real price of capital goods, P_k, must fall in order to induce a greater flow of resources into the production of consumables rather than capital goods thereby closing the excess demand gap in the consumption goods market.

In its efforts to maintain a constant price level P_m under the pressure of increased demand for consumption goods, the monetary authority must conduct an open market sale increasing the value of x. By exchanging bonds for money in the open market, the monetary authority causes an excess demand gap to open in the money market and an excess supply gap to open in the bonds market. In the three-asset model of Foley and Sidrauski in which real capital is the only real-asset alternative to the financial assets, the disequilibrium in the financial markets imparts upward pressure on the interest rate increasing the rate of return on bonds which tends to close the excess supply gap in the bonds market and the excess demand gap in the money market. The higher rate of interest simultaneously causes excess supply in the capital market as investors shift wealth into higher-yielding bonds.

The analysis of the three-asset model is shown graphically in Figure 4.1. Loci $m_o m_o$, $k_o k_o$, and $b_o b_o$ represent equilibrium combinations of the rate of return on bonds and the price of capital in the money, capital, and bond markets, respectively. All three markets are initially in equilibrium at point (P_{k_o}, ρ_{b_o}). An increase in the budget deficit lowers the equilibrium price of capital in the consumption goods market to P_{k_1}, the price of capital at which all three assets markets must clear if the chosen course of monetary policy is to be maintained. The effect of an open-market sale is shown graphically by a shift of the $m_o m_o$ locus to the northwest indicating that the money market will clear at a higher

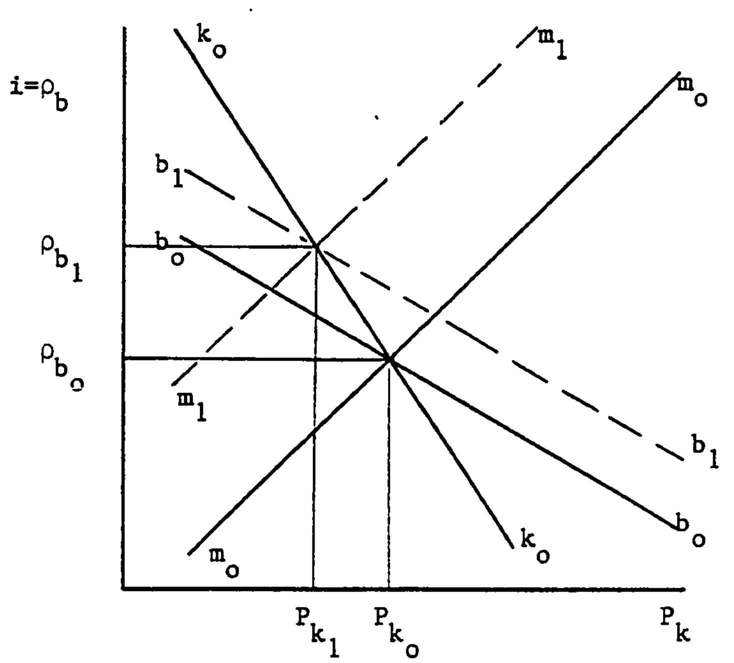


Figure 4.1. Determination of the equilibrium real rate of interest and the price of capital in the three-asset analog of Experiment One

interest rate or a lower price of capital and a shift of the $b_o b_o$ locus to the northeast indicating that the bond market will clear at a higher interest rate or a higher price of capital.

Equilibrium in all three markets is restored at a higher interest rate and a lower real price of capital at point (P_{k_1}, ρ_{b_1}). With the decline in the price of capital, the requisite increase in the flow of inputs to the production of consumption goods--at the expense of the production of capital goods--is attained. As the shift from the production of capital goods to the production of consumption goods occurs, equilibrium is restored to the consumption goods market.

When land is added to the model as a second real-asset alternative to financial asset ownership, the results of this experiment are unchanged with the important addition that the effect of the increase in the budget deficit on the price of land must now be resolved. As in the three-asset model, the increase in the budget deficit causes excess demand in the consumption goods market, a disequilibrium which requires that P_k decline given that P_m is pegged by the monetary authority. The differences in the analysis arising from the addition of land to the model become apparent when attention is turned to the effect of the decline in P_k in the assets markets.

Consider the capital market and land market equilibrium conditions, equations 4.15 and 4.16, respectively. Because the rate of return on money is fixed exogenously at zero and the price of capital is determined in the consumption goods market, these two equations are sufficient to determine the two remaining variables of the system, the rate of return on bonds, or the interest rate, and the rate of return on land which is inversely proportional to its price. The simultaneous determination of the equilibrium interest rate and price of land is shown graphically in Figure 4.2. Loci k_ok_o and l_ol_o represent equilibrium combinations of the real rate of interest and the price of land which leave the capital market and land market, respectively, in equilibrium given that the price of capital and the rate of inflation are held constant.

The decrease in P_k mandated by consumption market equilibrium following the increase in the current budget deficit causes excess demand to develop in the capital market due to the decline in the real value of capital on the supply side and an increase in the rate of return on capital on the demand side. The result is that locus k_ok_o shifts northwest to locus k_1k_1 to indicate that the capital market will clear at a higher interest rate or a lower price of land (higher return to land) following the drop in P_k. Similarly, with a decline in P_k and a corresponding increase in the rate of return on capital, excess supply develops in the land market. Equilibrium in the land market is restored by lowering the interest rate or increasing the rate of return to land by lowering its price, actions which are shown graphically by the southwest shift of locus l_ol_o to l_1l_1.

The results of the westward shifts in loci k_ok_o and l_ol_o are an equilibrium price of land which is unambiguously lower than its initial value and an equilibrium interest rate which could be either higher or lower than its initial level depending on the relative slopes and shifts of the equilibrium loci. The ambiguity associated with the real rate of

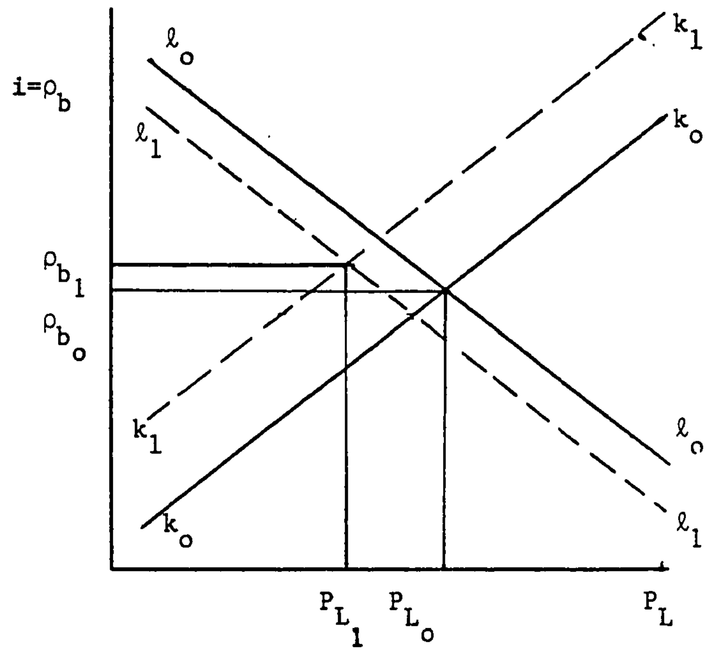


Figure 4.2. Determination of the equilibrium real rate of interest and land price in Experiment One

interest is resolved, however, by recalling that the initial disequilibrium in the assets markets was caused by an open market sale which caused excess supply in the bond market. Because lower prices of land and capital exacerbate that excess supply of bonds, the equilibrium interest rate must exceed its initial level to ensure that the bond market clears. These results, a lower price of capital, a lower price of land, and a higher interest rate in response to an increase in the value of the monetary control variable, x, corroborate the comparative statics derived algebrically in Appendix A and stated in equations 4.33 through 4.35.

In the long run, the economy is said to have reached a steady state when the per capita government debt level and the per capita capital stock are of constant magnitude, conditions which are defined by setting the right hand sides of equations 4.36 and 4.37 equal to zero. The long-run effects of a higher, constant budget deficit given that the monetary authority chooses to maintain a constant price level are summarized graphically in Figures 4.3 and 4.4. As shown in Figure 4.3, the steady-state government debt-to-labor ratio g is determined by the level of the budget deficit and the rate of growth of the labor force. An increase in the budget deficit from a level of d_o to d_1 shifts the line d_od_o up to d_1d_1 increasing the steady state per capita government debt to a level of g_1.

Curve cc of Figure 4.4 is the locus of combinations of k and P_k which allow the consumption goods market to clear. Locus cc is upward sloping because an increase in P_k shifts production out of consumption

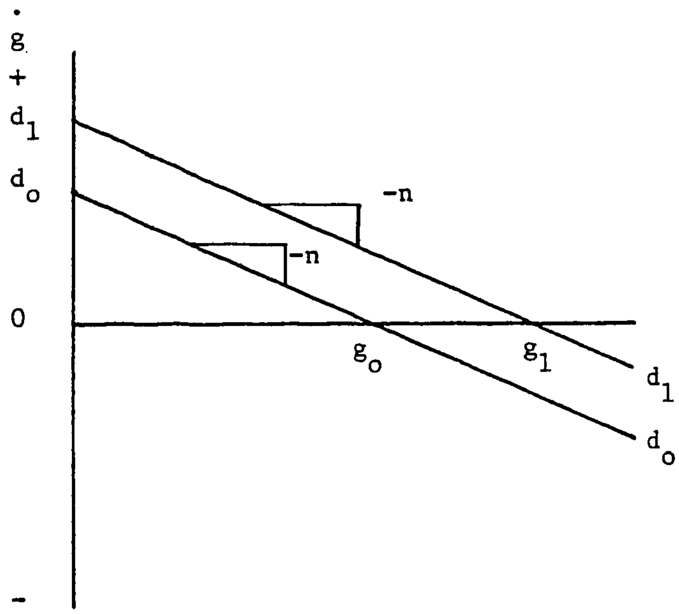


Figure 4.3. The effect of an increase in the fiscal deficit on the long-run stock of government debt

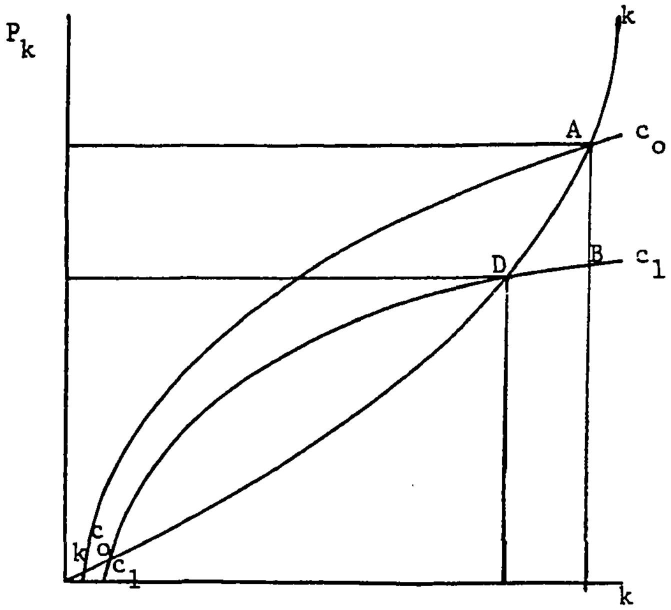


Figure 4.4. The effect of an increase in the budget deficit on the steady-state per capita stock of capital and its price

goods and into capital goods causing excess demand to develop in the consumption goods market. A simultaneous increase in k, under the assumption that production of consumption goods is more capital intensive than the production of capital goods, will restore equilibrium to this market by causing increased output of consumption goods and reduced production of capital goods. Formally, the derivative of P_k with respect to k along locus cc is positive as shown in equation 4.43.

$$(4.43)\quad \left.\frac{dP_k}{dk}\right|_{cc} = \frac{\frac{c}{1-c}\cdot P_k \cdot \frac{\partial q_I}{\partial k} - \frac{\partial q_c}{\partial k}}{\frac{\partial q_c}{\partial P_k} - \frac{c}{1-c}\cdot\left(\frac{\partial q_I}{\partial P_k}\cdot P_k + q_I\right)} > 0$$

Locus kk is the locus of combinations of P_k and k along which the per capita capital stock is constant. The argument for an upward sloping kk locus is the converse of that for an upward sloping cc locus; an increase in P_k results in a growing per capita capital stock from increased production of capital, and an increase in k reduces the rate of production of capital under the capital intensity assumption. The positive slope of the kk locus is verified by the derivative of equation 4.44.

$$(4.44)\quad \left.\frac{dP_k}{dk}\right|_{\dot{k}=0} = \frac{m - \frac{\partial q_I}{\partial k}}{\frac{\partial q_I}{\partial P_k}} > 0$$

As summarized in the discussion above, the increase in the budget deficit d creates excess demand in the consumption goods market at the initial level of P_k. The consumption goods market clears at a lower level of P_k shown by the shift of the cc locus to c_1c_1 in Figure 4.4. Because the consumption goods market, the flow constraint, must clear at each instant of time, the result of the increase in the fiscal deficit is a discrete fall in P_k from point A to point B followed by a gradual decline in P_k and in the size of the per capita capital stock from k_o to k_1 as the economy moves along the c_1c_1 locus to the new steady state at point D.

In the new steady state, a larger per capita stock of government debt is associated with a smaller per capita stock of capital. The smaller per capita stock of capital is a result of the fact that the lower P_k does not call forth sufficient production of the capital good to maintain the capital stock at k_o; the reduced level of capital good production is capable of maintaining a smaller per capita stock of capital in the economy. As the economy moves toward the new steady state, the growing per capita stock of government debt and the declining per capita stock of capital raise the equilibrium price of capital in the assets markets widening the difference between the market-clearing value of P_k in the assets markets from that in the consumption goods market. To lower the equilibrium value of P_k in the assets markets to the level of P_k which clears the consumption goods market, the monetary authority must continuously increase the value of x increasing the interest rate and lowering the price of land as well as the price of capital as discussed above.

Experiment Two: An Increase in the Target Rate of Inflation

Experiment One represents the extreme case in which the monetary authority would tolerate no inflation of the price of the consumable. In Experiment Two, however, the model is modified slightly to allow a fixed rate of inflation greater than zero in a world of perfectly anticipated inflation. That is, the target level of inflation is that which actually appears in the economy, and all transactors in the economy are aware of the inflation target and are convinced that the government will maintain that target.

To accommodate this macroeconomic policy assumption, equations 4.45 and 4.46 replace equations 4.40 and 4.42, respectively. Equation 4.45 allows for a nonzero rate of deflation, π_m, and for the purposes of this experiment the target rate of deflation is assumed to be negative. Rather than to target a specific fiscal deficit level d*, the value of the deficit is adjusted to a level which will maintain the real value of the stock of government debt regardless of the rate of deflation as shown in equation 4.46. That is, if the government chooses to increase the target rate of inflation (reduce the magnitude of π_m) which increases the rate of capital loss on the stock of government debt over time, the current deficit must increase to maintain the real value of the stock of government debt as time passes.

(4.45) $\pi_m = \pi_m{}^*$

(4.46) $(d + \pi_m g)\ P_m = nP_m g$ [1]

Assume that with the economy in steady state, the monetary authority increases the target rate of inflation (π_m declines) and that the government increases the current fiscal deficit d so that equation 4.46 holds. Unlike the development of the previous experiment, the offsetting nature of the simultaneous increase in the deficit and the target rate of inflation leaves the consumption goods market in equilibrium. The

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[1]The steps in the derivation of 4.46 are:

$$\frac{(g\dot{P}_m)}{gP_m} = \frac{\dot{g}}{g} + \pi_m = 0$$

$$\frac{\dot{g}}{g} = \frac{\dot{G}}{G} - n$$

$$d = \frac{\dot{G}}{N}$$

$$\frac{\dot{g}}{g} = \frac{d}{g} - n$$

$$\Rightarrow \frac{d}{g} + \pi_m = n$$

$$\therefore (d + \pi_m g)P_m = nP_m g$$

increase in the rate of inflation does, however, lower the rate of return on money and bonds throwing the assets markets out of equilibrium and causing investors to shift wealth out of financial assets and into existing real asset alternatives.

In the Foley and Sidrauski three-asset model, capital is the only alternative to the financial assets as a means of holding real wealth, and in response to increased investor demand, the price of capital is bid higher. A higher price of capital would shift the flow of resources towards the production of capital goods rather than consumption goods resulting in excess demand in the consumption goods market. Assuming that the monetary authority will allow no instantaneous jump in P_m along its long-run time path determined by equation 4.45, an open-market sale must take place to hold the price of capital in the assets markets at its initial level, the value which maintains equilibrium in the consumption goods market.

As was the case in the previous experiment, the excess demand for money and the excess supply of bonds resulting from the open-market sale pushes the rate of return on bonds higher inducing a shift of wealth from the real asset, capital, back to the financial assets. If capital is the only real asset alternative to the financial assets, the nominal interest rate must increase by more than the increase in the rate of inflation to restore the price of capital to its initial level. That is, the real rate of interest must rise. If the increase in i were exactly equal to the increase in inflation, the rate of return on bonds would be unaltered, but the lower rate of return on money would cause excess demand in the capital market at the initial price of capital.

The graphical solution to this experiment is shown in Figure 4.5 in which the three initial equilibrium loci m_om_o, k_ok_o, and b_ob_o are identical to those of Figure 4.1. With a decline in the rate of deflation, locus m_om_o shifts southeast indicating that the money market will clear at a lower rate of return on bonds or a higher price of capital. Similarly, locus k_ok_o shifts northeast to indicate that the capital market will clear at a higher interest rate or a higher price of capital. Finally, locus b_ob_o shifts southwest to show that the new equilibrium in the bond market occurs at a lower real interest rate or a lower price of capital. The new simultaneous equilibrium in all three markets is attained at a lower real interest rate and a higher price of capital, point (P_{k_1}, ρ_{b_1}). Clearly, the effect of an increase in the rate of inflation in the assets markets is an increase in the price of capital, an event which is not consistent with equilibrium in the consumption goods market as noted above.

The effect of the open-market sale of bonds by the monetary authority is to shift the new m_1m_1 locus towards its initial position. However, the open-market operation also creates excess supply in the bond market shifting locus b_1b_1 northeast. Equilibrium combinations of the interest rate and the price of capital in the capital market are unaffected by the change in monetary policy, and locus k_1k_1 remains in place. With the proper adjustment of the monetary control variable, x, all markets return to equilibrium at a higher interest rate, ρ_{b_2}, and the

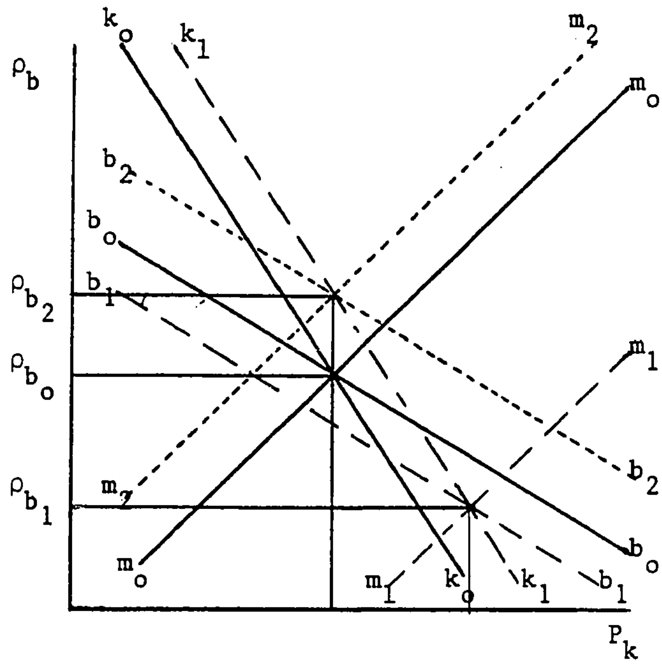

Figure 4.5. Determination of the equilibrium rate of interest and the price of capital in the three-asset analog of Experiment Two

initial price of capital, P_{k_o}, the price which is consistent with consumption market equilibrium.

The analysis of this experiment following the inclusion of land as an additional real asset alternative to financial asset ownership is similar to the analysis of the full, four-asset model in Experiment One. In Experiment Two, the differences between the analysis of the three-asset model and the four-asset model including land arise from the effects of the increase in the rate of inflation in the assets markets. Given that the price of capital determined in the consumption goods market is pegged in the assets market by open-market operations and that the rate of return on money is determined exogenously as well, the capital market and land market equilibrium conditions, equations 4.15 and 4.16, together determine the equilibrium real rate of interest and the price of land.

The simultaneous determination of the real rate of interest and the price of land is shown graphically in Figure 4.6 in which equilibrium loci $k_o k_o$ and $l_o l_o$ are defined and drawn exactly as they are in Figure 4.2. When the target rate of inflation is increased and an open market sale is initiated to maintain a constant price of capital, the lower rate of return on money causes excess demand to develop in the capital and land markets. Locus $k_o k_o$ shifts northwest to indicate that the capital market will clear at a higher return on bonds or a higher return on lower priced land following the increase in inflation. Similarly, locus $l_o l_o$ shifts northeast to indicate that equilibrium in the land market, given

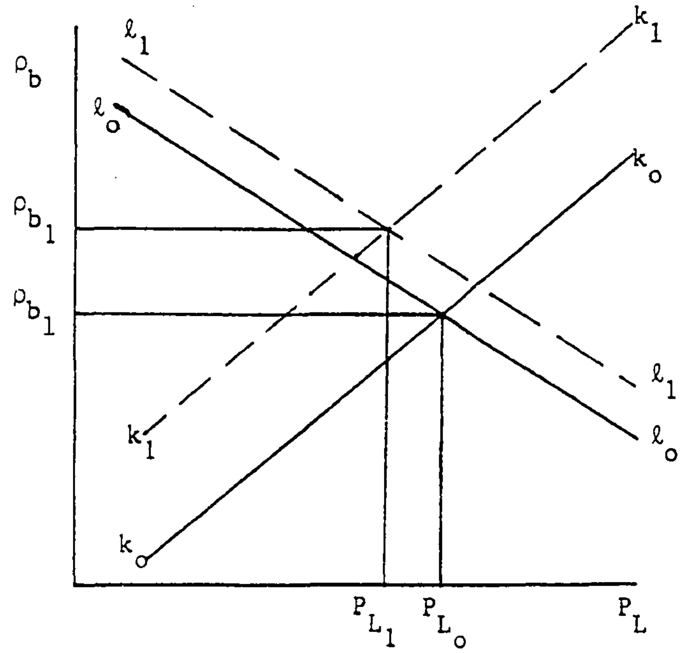

Figure 4.6. Determination of the equilibrium real rate of interest and land price in Experiment Two

an increase in the inflation rate, will occur at a higher interest rate or a lower rate of return on higher priced land.

Clearly, the real rate of interest is higher than its initial value, and the price of land could be either higher or lower than its initial value depending on the relative slopes and shifts of the equilibrium loci of Figure 4.6. The equilibrium price of land will fall from its initial value if the $k_o k_o$ locus shifts north farther than does the $l_o l_o$ locus for any exogenously specified increase in the target rate of inflation. If the northward shift of locus $k_o k_o$ does exceed that of locus $l_o l_o$, the decline in the price of land will be greater the flatter are the $k_1 k_1$ and $l_1 l_1$ loci.

These results again verify the comparative statics derived in Appendix A for the system of equations 4.13 through 4.16 and presented in equations 4.33 through 4.35. An exogenous increase in the rate of inflation (a decrease in the value of π_m) taken by itself would tend to increase the price of capital, the price of land, and the rate of interest prevailing in the assets markets. In this experiment, however, the requirement that the price of capital remains fixed as determined in the consumption goods market dictates that the monetary control variable x increases when the target rate of inflation is increased. An increase in x taken alone would tend to lower the price of capital and the price of land while increasing the rate of interest. The simultaneous increase in the rate of inflation and the monetary control variable x results in the ambiguity with respect to the equilibrium price of land.

A larger northward shift of the $k_o k_o$ locus than that of the $l_o l_o$ locus indicates that a greater increase in the real rate of interest is required to restore equilibrium in the capital market than in the land market (at constant prices of capital and land) as investors shift real wealth from the financial assets to the real assets in response to the increase in the rate of inflation. This would suggest that the preferred inflation hedge for liquid assets is real capital and/or that the demand for capital is not as interest-rate sensitive as the demand for land. Because the liquidity characteristics of capital are intermediate to those of the financial assets and land, the assumption that real capital would be the preferred inflation hedge seems plausible.

Flat ll loci would suggest that demand for land is highly interest-rate sensitive. That is, if the magnitude of the elasticity of the demand for land with respect to the interest rate is large, a relatively small increase in the real rate of interest would cause a large decline in the price of land. The meaning of the slope of the kk locus is slightly more complicated. A flat kk locus means that a relatively small increase in the real rate of interest must be met with a large increase in the price of land to maintain equilibrium in the capital market. Stated more formally, a flat kk locus would suggest that the magnitude of the elasticity of the demand for capital with respect to the interest rate is large and/or that the magnitude of the elasticity of the demand for capital with respect to the price of land is small. These assumptions required to ensure relatively flat slopes of the kk and ll loci appear plausible.

In summary, a simultaneous increase in the current budget deficit and the rate of inflation given that the price of capital is held fixed by the actions of the monetary authority will result in an increase in the real rate of interest. The real price of land in this experiment could move either higher or lower. However, reasonable assumptions regarding the magnitudes of the effects of an increase in the rate of inflation and the real interest rate in the assets markets suggest that the real price of land would decline.

A Hypothesis Drawn from Experiments One and Two

In Experiment One, an increase in the size of the current budget deficit given a monetary policy goal of maintaining a constant zero rate of inflation results in an increase in disposable income which induces an expansion in demand for consumption goods. To maintain a constant price level, the monetary authority is forced to conduct an open market sale which increases the rate of interest and drives the prices of real assets, capital and land, to lower levels. In the long run, the increase in the budget deficit results in a higher per capita stock of government debt, and the reduction in the price of capital results in a reduced rate of accumulation of capital and therefore a smaller per capita capital stock. As the economy moves to its eventual steady state, the monetary authority is forced to continually tighten the money supply pushing the interest rate higher.

The scenario of Experiment Two is nearly identical to that of Experiment One with the exception that an increase in the current budget deficit does not increase disposable income due to a simultaneous increase in the target rate of inflation. Higher inflation translates into capital losses on holdings of government debt, losses which exactly offset any increase in disposable income arising from a greater current deficit. The result of the monetary authority's policy of allowing the target rate of inflation to rise just enough to maintain a constant real value of the stock of government debt is the maintenance of equilibrium in the consumption goods market at a constant price of capital.

However, a greater rate of inflation does cause disequilibrium in the assets markets forcing the monetary authority to tighten the money supply through open market sales exactly as in Experiment One. Rather than to drive the price of capital to a lower level as in Experiment One, the goal of the open-market operation is to maintain the price of capital at its initial level. In this instance, the interest rate rises as in Experiment One, but the effect of the expansion of the deficit and the ensuing tight money policy on the price of land cannot be determined analytically and remains an empirical issue.

In the long run, neither the per capita stock of real government debt nor the capital-labor ratio are changed from the initial levels. The real value of the outstanding government debt does not change in either the short- or the long-run with an increase in the current deficit because capital loss on the government debt increases with a compensating increase in the rate of inflation. Because the price of capital is held constant, the rate of accumulation of capital (per capita) does not change through time, and the capital-labor ratio also remains at its initial level. The real rate of interest is higher in the long run as well as in the short run in order to curtail the increase in demand for capital that would otherwise accompany an increase in the rate of inflation. As in the short run, the long-run impact of these macroeconomic policies on the price of land is an empirical issue.

In both experiments monetary policy objectives are attained through an open-market sale (increase in the value of x) which increases the real rate of interest and drives the price of capital to a level consistent with that determined in the market for consumption goods. The equilibrium prices of capital and land are below the initial prices in Experiment One as the monetary authority maintains a zero level of inflation in the face of a larger fiscal deficit. The somewhat more accommodative monetary policy of Experiment Two in which the target rate of inflation is allowed to increase with the fiscal deficit results in no change in the equilibrium price of capital and an equilibrium price of land which is not necessarily lower than its initial value.

The model developed above provides a firm theoretical basis for investigating the effect of an expansionary fiscal policy, taking the form of an increase in the current budget deficit, working in concert with a restrictive monetary policy on the value of land. The two foregoing experiments suggest that the more restrictive is monetary policy in regard to holding increases in the rate of inflation in check as the budget deficit rises, the greater will be the decline in real asset values, notably the value of capital and land.

In view of the results of these two experiments, one can readily hypothesize that the decline in real asset values would be even greater than that determined in Experiment One if the monetary authority sought to actually decrease the rate of inflation rather than to maintain a zero rate of inflation in the face of an increasing fiscal deficit. The simultaneous increase in the fiscal deficit and the decrease in capital losses on the stock of government debt provided by a reduced rate of inflation would provide a large boost to disposable income and to demand for consumption goods. An increased output of consumption goods is obtained by diverting resources from the production of capital goods to the production of consumption goods, a diversion which is accomplished by reducing the price of capital goods. As in Experiments One and Two, a lower price of capital goods--and a lower price of land--is obtained through an open market sale which drives the real rate of interest to a higher level inducing a shift of wealth from the real assets to the financial assets.

In summary, the theoretical model specified in this chapter provides a basis for the hypothesis that an expansionary fiscal policy conducted in concert with a restrictive monetary policy has an adverse effect on the value of real assets, notably the price of land. To test this hypothesis and the validity of this portfolio-balance model as a means of explaining variations in the value of farmland, an empirical model based on the theoretical model described above must be constructed. The construction of the empirical model is the topic of the following chapter.

CHAPTER FIVE: THE SPECIFICATION OF THE EMPIRICAL MODEL

The objective of Chapter Five is to introduce the empirical methods which are used in Chapter Six to test the theoretical relationships between macroeconomic policy and the price of farmland which were developed in the conceptual model of Chapter Four. The first section of this chapter provides a summary of these hypothesized relationships. The data series which are used in the empirical tests of the theory of Chapter Four are described in the second section. A third section introduces the empirical model itself and provides a brief review of the methods of vector autoregression (VAR), the econometric technique applied in Chapter Six.

Hypothesized Channels of Macroeconomic Policy

A reasonable, brief summary of the results provided in the discussion of the conceptual model of Chapter Four is that the initial effect of an expansionary fiscal policy conducted in an environment of monetary restraint is an increase in the real rate of interest. Subsequent portfolio-balancing activity by wealth holders in the economy results in increased demand for financial assets, reduced demand for real assets, and, finally, an equilibrating reduction in the price of real assets, notably farmland. Therefore, in the model of Chapter Four, portfolio-balancing activities of wealth holders induced by a shift in the real rate of interest serves as the channel linking macroeconomic policy to the price of farmland.

A second channel through which the effects of macroeconomic policy could reach the agricultural sector was discussed briefly in Chapter One but is not addressed explicitly by the theory of Chapter Four. This channel links the policy-induced increase in the real rate of interest to land value through the exchange rate and returns to land. That is, a policy-induced increase in the real rate of interest in the United States imparts upward pressure on the exchange value of the U.S. dollar. The increase in the exchange rate (foreign currency/U.S. dollar) drives a wedge between the price of U.S. agricultural commodities on world markets and the price of those commodities in domestic markets. The subsequent reduction in demand for U.S. agricultural commodities leads to a corresponding reduction in the income return accruing to land and other farm production assets. Finally, the value of land, being directly associated with the value of the income stream which it commands, declines as well.

This circuitous, second channel of macroeconomic policy described above is admittedly a speculative hypothesis, inasmuch as the conceptual model of Chapter Four is not an open-economy model providing a firm, theoretical basis for considering effects involving the exchange rate. Other hypotheses of the linkage of macroeconomic policy to returns to land could be proposed; however, the most plausible hypothesis is that macroeconomic policies which tend to increase the real rate of interest will tend to lower returns to land.

As a concluding note on this second channel through which macroeconomic policy is hypothesized to affect land value, recall the Chapter

One review of the current debate concerning the effects of general price inflation on the short-run terms of trade of the agricultural sector. If one is willing to make the plausible assumptions that a positive money supply shock is associated with inflation and that an improvement in agriculture's terms of trade is associated with an increase in returns to land, then the second channel of macroeconomic policy described above is consistent with the argument and empirical findings of those, especially Starleaf, Meyers, and Womack, and Falk, Devadoss, and Meyers, who assert that an increase in the rate of inflation improves agriculture's terms of trade. That is, the logic underlying channel two carries the effect of a positive money supply shock beyond an improvement in terms of trade to an increase in returns to land and finally to an increase in land value consistent with the capitalization models of Chapter Two.

Note that the effect of macroeconomic policy on the value of land is the same regardless of which of these two channels links the policy shock to land value. Moreover, the second channel linking the policy shock to land value through returns to land is not entirely distinct from the pure portfolio-balance effect. A decline in returns to land, all else held constant, leads to a decline in land value as investors shift wealth into alternative assets in another manifestation of the portfolio-balancing behavior upon which the conceptual model is built.

These two channels relating macroeconomic policy to the value of land serve as the basis for several hypotheses regarding relationships among several of the key variables of the model of Chapter Four. The variables of interest are the fiscal deficit of the federal government, the money supply, the real rate of interest, the stream of returns accruing to the land owner, and finally, the price of land. First of all consider a positive shock to the fiscal deficit. If the monetary authority refuses to accommodate the increase in the deficit through monetization, then the real rate of interest, according to the theory of Chapter Four, should rise. Channel one, portfolio-balancing behavior, leads directly to a decrease in the value of farmland. Channel two, the more circuitous route through returns to land, also leads to a decline in the value of land.

Next consider a positive money supply shock. According to the conceptual model, a money supply shock should put downward pressure on the real rate of interest and at least mitigate any increase in the real rate of interest caused by an expansion of the fiscal deficit. Channel one leads to a direct increase in the price of land through portfolio-balancing behavior, and channel two leads to an indirect increase in the price of land through an increase in the income return to land.

Finally consider a shock to the real rate of interest or a shock to the stream of returns accruing to land. As discussed above, a shock to the real rate is expected to cause a direct decrease in the price of land via channel one and an indirect decrease in the price of land via channel two. A returns shock is, of course, expected to cause the price of land to rise.

The Data

Six series of annual data for the years 1929 through 1985 are used in the empirical tests of the validity of the hypotheses discussed in the preceding paragraphs. The availability of data series of returns to land and land value limited the data choice to annual data. The lengthy time series was chosen to support the VAR modeling technique, a technique which requires a relatively large number of observations as is shown in a following section of this chapter. Indeed, if the land returns and value series used in the estimation of the model were available for years prior to 1929, additional observations would have been used. Ideally, the data series would include the period of the significant surge and subsequent decline in land values during the second and third decades of the century as well as the period of the land market cycle of the 1970s and 1980s.

The first data series, Deficit, is the calendar-year, fiscal deficit of the federal government of the United States as it is recorded in the National Income and Product Accounts. Deficit data for the years 1929 through 1938 were found in Historical Statistics of the United States (U.S. Department of Commerce, 1975), and data for years 1939 through 1969 are those reported in Reagan (1985). The most recent deficit data, years 1970 through 1985, were obtained from the data base maintained by Wharton Econometric Associates and accessed electronically through the facilities of the Food and Agricultural Policy Research Institute at Iowa State University.

The second series, M1, is the monetary aggregate M1, the money supply measure which includes checkable deposits and currency in the hands of the public and is generally considered to represent transactions balances. Recall that the variable X, the ratio of monetary base to the total stock of government debt, was used as the indicator of monetary policy in the theoretical model, an indicator chosen primarily for analytical convenience. M1 rather than the variable X, however, was chosen as the indicator of monetary policy in the empirical model because M1 is the more widely reported and accepted indicator used in empirical research. M1 data for the years 1929 through 1958 are annual averages of estimates made by Friedman and Schwartz (1970) as recorded in Historical Statistics. Data for the remaining years of the series, 1959 through 1985, are twelve-month averages of the monthly averages of daily data obtained from Wharton Econometric Associates.

The real rate of interest, denoted: RRate, is derived from two data series. This ex post estimate of the real rate is calculated as the difference between the nominal interest rate in year t and the rate of inflation in year t. Adjustment of the nominal rate of interest by the contemporaneous rate of inflation follows the notion of perfect foresight with regard to expectations of the rate of inflation in the theoretical model. The nominal interest rate is the annual average yield on Moody's grade Aaa corporate bonds from 1929 to 1985 as reported in Historical Statistics for years 1929 through 1939, Reagan for years 1940 through 1984, and the Federal Reserve Bulletin for the year 1985. All interest rate data are yearly averages of daily data with the exception that the average interest rate for the year 1985 is calculated from data for only the first eleven months of the year. The rate of inflation is measured by the first difference of the natural logarithms of the implicit price deflator (IPCE) for the personal consumption expenditures component of

GNP reported in Historical Statistics for years 1929 through 1939, Reagan for years 1939 through 1984, and Survey of Current Business for 1985.

The final two data series used in the analyses are measures of returns to farmland and of farmland value. As discussed in Chapter One, by definition the measure chosen to represent returns to farmland must not include returns to other production assets. Two principal indicators of farmland returns are available, a series of gross cash rents compiled by the Statistical Research Service of the United States Department of Agriculture (SRS/USDA) and reproduced in part in the dissertation of Flowers (1983) and a series of returns to farm production assets constructed by and obtained from Emanuel Melichar of the Board of Governors of the Federal Reserve System.

The primary advantages of Melichar's data series are its length, years 1910 through 1984, and the fact that it is an aggregate series for the entire agricultural sector. Melichar's series, however, is derived through the residual method by adjusting net farm income to more accurately reflect returns to land. The adjustments include the subtraction of estimated returns to operator's labor and management and estimated returns to equity in farm dwellings and the addition of net rental income of landlords and interest paid on all farm debt. The residual is assumed to be returns to farm production assets, the primary component of which is farm real estate. Unfortunately, this residual also contains any error in the chain of estimates used in its derivation.

Gross cash rent, a direct, market-determined measure of returns to land, is not subject to the problem of accumulating error found in the residual return series. The primary problems in using gross cash rent as the measure of returns to land in this study are: 1) property taxes and depreciation of fixed improvements have not been netted out of the series, 2) the series of gross cash rents is available for only the years 1929 through 1985, 3) the gross cash rent series is not available for all states nor has an average gross cash rent been calculated across all states for which data are available, and 4) the parcels of land from which state-average gross cash rents and land values are calculated change through time so that the data are not perfectly comparable from year to year.

In spite of these shortcomings, the series of gross cash rents was chosen as the measure of returns to land to be used in these empirical investigations. The series is compiled in the Annual Farm and Ranch Report Survey in which survey participants are asked to report both land value and gross cash rent for land which is rented for cash with no distinction made between the value of crop land, pasture, or fixed farm improvements. The direct correspondence of this returns series with the associated land value series is the primary reason for its inclusion in this study at the expense of Melichar's residual returns measure. The residual returns series was tested in early model runs, but the generally low level of association between this returns measure and the average price of farmland in the United States was considered unacceptable in view of the capitalization models of Chapter Two and led to the choice of the alternative gross cash rent series.

The problems noted in using the series of gross cash rents are not insurmountable. First, previous land value studies (Flowers, 1983, and Walker, 1979) have found gross cash rents to be a reasonable proxy for net cash rents. Second, although a longer data series is preferred, the 1929 through 1985 series was found to be of adequate length to provide for convergence of the model.[1] Finally, an aggregate series of gross cash rents, Returns, was constructed from the annual, state-wide averages of the SRS/USDA survey by weighting each annual state average by the total land in farms in the state as reported in Agricultural Statistics. Weights for years in which land in farms is not reported were derived by linear interpolation.

The final series used in the estimation of the empirical model is Value, the value of the land associated with the cash rent series, Returns. The Value series is a weighted-average value computed from state-wide averages using the same weights applied in computing the Returns series. Annual cash rent and land value data for eleven states were used in computing the aggregate averages. Although the SRS/USDA survey includes gross cash rent and land value data for a total of 24 states, Flowers included in her study only those states which had a well-developed cash rental market: Ohio, Indiana, Illinois, Iowa, Missouri, Pennsylvania, Minnesota, South Dakota, Michigan, Wisconsin, North Dakota, and Oklahoma. The survey was discontinued in Oklahoma after 1981.

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[1]Trial model runs indicated that a VAR model supported by a series length which provided a number of residual degrees of freedom in the estimation of each equation which was less than the number of parameters estimated per equation tended to be explosive.

Therefore, data for those eleven states listed above, Oklahoma excluded, are used in this study.

Note that with the exception of Pennsylvania, these states are clustered in the predominantly rural, extensively agricultural, central region of the United States. In addition, this sample of states includes the states of the "Corn Belt", Ohio, Indiana, Illinois, Iowa, Missouri, and Minnesota, which have experienced variation in the value of farm real estate significantly greater than that of the United States as a whole (compare Figures 1.1 and 5.2).

Gross cash rent and land value data for the years 1929 through 1980 were obtained from Flowers, and data for the years 1981 through 1985 were obtained from the Land Branch, Natural Resources Division, Economic Research Service, United States Department of Agriculture. All six data series described above--nominal values of Deficit, M1, Returns, and Value, the Moody's Aaa bond rate, and the deflator IPCE--are provided in Appendix B. Recall that plots of the real rate of interest RRate, the annual percentage change in nominal M1, and the real Deficit series are shown in Figures 1.3, 1.4, and 1.5, respectively, and note that plots of the real Returns and real Value series are shown in Figures 5.1 and 5.2

Nominal values of Deficit, Returns, and Value were first deflated to real values (constant 1972 dollars) using the IPCE. The series of nominal M1, real Returns, and real Value were then transformed to series of annual percentage changes approximated by first taking natural logarithms and then first differencing. Finally, all five series were regressed, using ordinary least squares (OLS), on a constant, the value

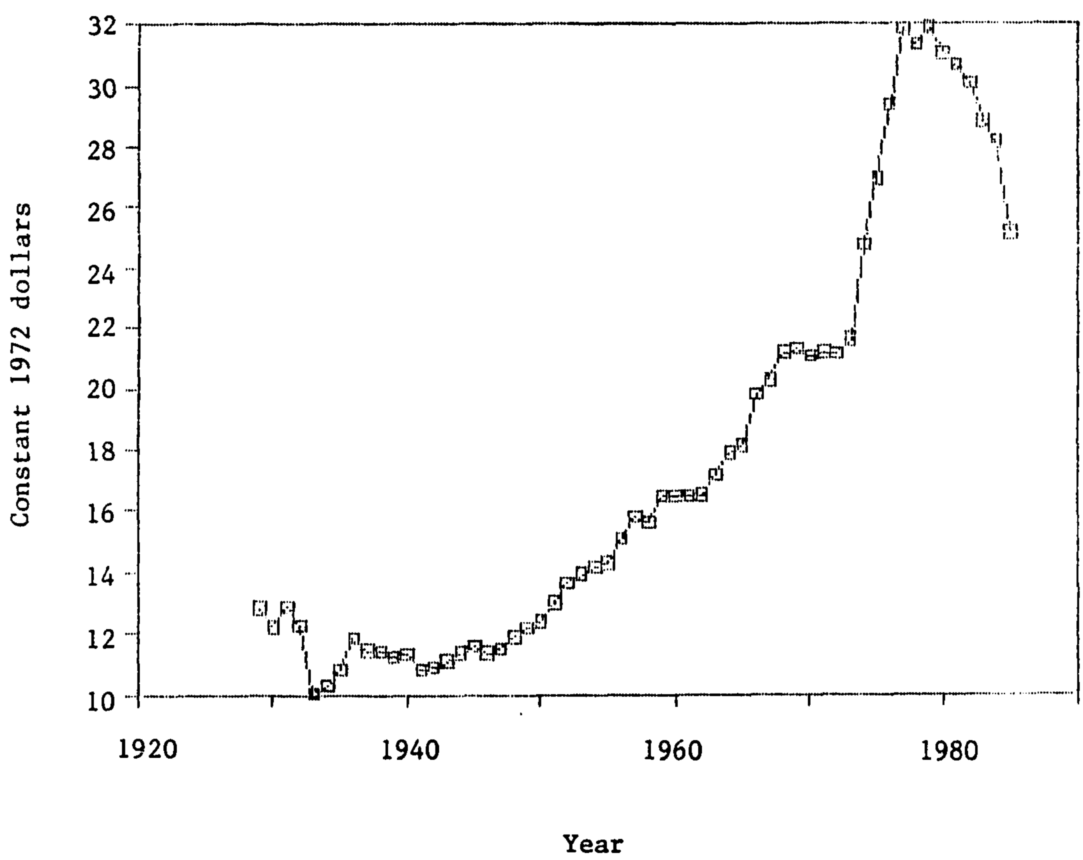

Figure 5.1. Weighted-average, real gross cash rent per acre for eleven selected states

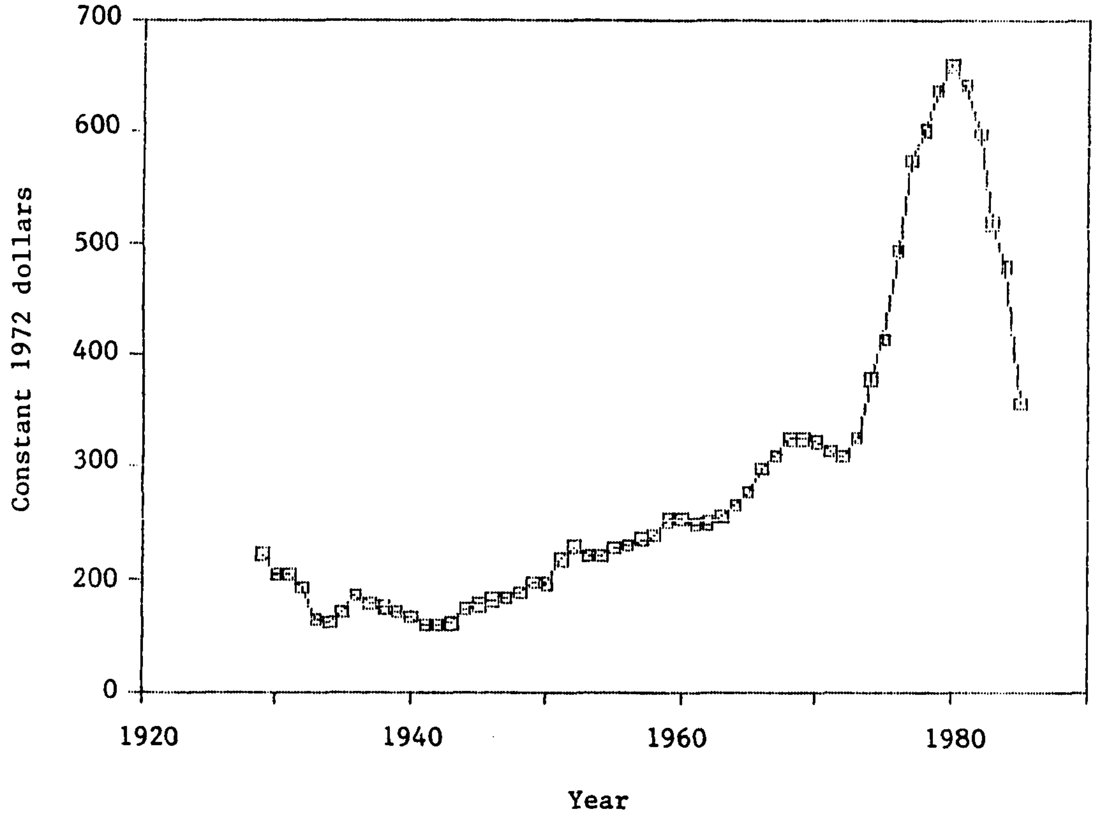

Figure 5.2. Weighted-average, real value per acre for eleven selected states

of the year or trend, the square of the trend term, and a dummy variable of value 1 during the years of World War II, 1942 through 1945, and of value 0 in all other years. The residuals from the OLS regressions are the series which enter the VAR models described in following sections of this chapter. The transformation of the data to percentage changes and the detrending procedure were performed to ensure stationarity of the empirical model. Plots of the transformed, detrended series did not reveal significant departures from the assumption of stationarity.

The VAR Model

Recall that the conceptual model derived in Chapter Four to explain the association of macroeconomic policy with the value of farmland is a dynamic, simultaneous model of nine equations (4.30 through 4.38) in nine unknowns, q_c, q_I, P_k, P_L, i, X, $\dot{k}$, $\dot{g}$, $\dot{i}$. Sims (1980) and other economists who have adopted the techniques of empirical analysis which Sims has developed, for example Bessler (1984a, 1984b), Burbidge and Harrison (1984), Chambers (1984), Falk (1983, 1985), and Falk, Devadoss, and Meyers (1986), argue convincingly that the exclusionary and exogeneity restrictions which would typically be applied to this model in traditional econometric procedures of specifying and identifying the structural model are neither credible nor innocuous. The essence of the argument is that the results of traditional macroeconomic modeling efforts are compromised by spurious reflections of the imposition of restrictions based on "supposed a priori knowledge" (Sims, 1980). The danger is that existent regularities in the data are not discovered.

The approach adopted in the empirical investigations of this study follows that pioneered by Sims, an approach which avoids the imposition of ad hoc zero/one restrictions on structural parameters. Instead, reduced-form expressions in which every variable is allowed to influence every other variable with lags are estimated with the goal of "allowing what regularities are present in the data to reveal themselves" (Bessler, 1984a). The empirical model chosen to test the validity of the theoretical relationships between macroeconomic policy and the value of farmland identified in the conceptual model of Chapter Four and clarified in the hypotheses of an earlier section of this chapter is shown in equation 5.1. X(t) is assumed to be a covariance-stationary, vector-valued time series, and U(t) is a zero-mean innovation vector. The roots of the characteristic equation $\mathrm{Det}[I - A(Z)] = 0$ are assumed to exceed one in modulus to assure stationarity of X(t), a generalization of the condition that the autoregressive coefficient in an AR(1) model must be less than one in absolute value. The elements of U(t) may be contemporaneously correlated but are assumed to be intertemporally independent as specified in equations 5.2 and 5.3.

$$(5.1) \qquad [I - A(L)]\,[X(t)] = U(t)$$

where: $$X(t) = \begin{bmatrix} \text{Deficit}\ (t) \\ \text{M1}\ (t) \\ \text{RRate}\ (t) \\ \text{Returns}\ (t) \\ \text{Value}\ (t) \end{bmatrix};$$

$A(L) = A(1)L + A(2)L^2 + \ldots + A(n)L^n$;

$A(s)$ is a 5x5 matrix of constants for $s=1, \ldots, n$;

$U(t)$ is the 5x1 innovation vector; and

t is the discrete time index.

$$(5.2) \qquad E[U(t)] = \underset{5\mathrm{x}1}{0} \quad \text{for all } t$$

$$(5.3) \qquad E[U(t)U(s)'] = \begin{cases} \underset{5\mathrm{x}1}{0} & \text{for all } t \neq s \\ \underset{5\mathrm{x}5}{\Sigma} & \text{for } t=s \end{cases}$$

In this autoregressive representation of the model, past values of each of the five dependent variables of the X vector enter the individual equation for each of the five variables without restriction. The development of the conceptual model provides little if any motivation for the appearance of lagged values of Returns and Value in the equations for Deficit and M1, variables which are assumed to be exogenous to the rest of the model. Nonetheless, coefficients of Returns and Value were not restricted to zero in the Deficit and M1 equations because the imposition of these restrictions would be a violation of the spirit of this unrestricted modeling effort. Similar logic prevailed in the maintenance of complete symmetry of the lag length n across all variables in all equations. Thus, the fundamental characteristics of the "vector-autoregression model" (VAR) as devised by Sims are preserved.

The form of system 5.1 dictates the estimation of many structural parameters, a condition which lead Sims to describe the VAR model as "profligately" parameterized. As mentioned briefly in the discussion of the choice of data series in the preceding section, lengthy time series are required to provide sufficient degrees of freedom for estimating the numerous parameters of model 5.1. Indeed, data limitations can easily place an upper bound on the number of lags considered in the equations of system 5.1. This is especially true for data which are available only as annual series. Researchers who are afforded the luxury of working with data available as reliable monthly or even quarterly time series can find sufficient observations in a much shorter time span for the efficient estimation of a VAR model.

The relevance of this point for this study is that the availability of only annual data for land value and returns precludes the confining of the period of estimation of model 5.1 to the period of the extraordinary land price movements of the 1970s and 1980s. Rather, a much longer estimation period must be employed, a period which includes the depression of the 1930s and the war of the 1940s as well as all other structural changes which occurred in the economy during the years 1929 through 1985. Falk (1985), however, suggests that the severity of this limitation of the VAR model in applications of this sort must be weighed against the benefit of the avoidance of unjustified restrictions which facilitate the use of shorter estimation periods in the application of more traditional econometric techniques. The extent of the impact of this period-of-estimation constraint will become apparent in the discussion of the empirical results in Chapter Six.

The elements of the estimated matrices A(s), s = 1,...,n, are not sufficiently interesting in themselves to be reported in most VAR applications. Instead, the estimated VAR model is used to simulate the system's dynamic response to shocks in certain variables in the system. Given the model described in equations 5.1 through 5.3, two techniques of "innovation accounting" commonly used in VAR applications are used in this study. The first is the determination of impulse responses or the response of each of the dependent variables to shocks in the other variables. The second technique employed is the decomposition of the variance of the forecast error, a type of causality test. The next two subsections describe these two techniques, and the third subsection addresses a final empirical issue, the determination of the appropriate lag length to use in model 5.1. The primary references for these next three subsections explaining the techniques of innovation accounting are Bessler (1984a, 1984b), Chambers (1984), Falk (1983, 1985), and Falk, Devadoss, and Meyers (1985).

The determination of impulse responses

This technique of innovation accounting allows the analyst to study the impact of a one-time, unit shock in one of the components of the VAR model on the values of the other components of the model over time. An example of the derivation of the impulse responses for a simple model with an X vector of only two components is provided in equations 5.4 through 5.12.

The n-order AR representation of this abbreviated model is shown in equation 5.4. Assume the analyst wishes to determine the response of the system to a unit shock in the second component of the system, X_2. In equation 5.5, all past values of the X vector and all components of the current innovation vector are set equal to their expected value of zero except for that component of the innovation vector, U_2, providing the unit shock to the system. The system is then shifted forward through time, step by step, to trace the response of the X vector to the single, unit shock in U_2 at time zero. The values of the X vector, the impulse responses, at the first and second steps after the shock are shown in 5.6 and 5.7, respectively.

$$(5.4)\quad \begin{bmatrix} X_1(0) \\ X_2(0) \end{bmatrix} = \begin{bmatrix} a_{11}(1) & a_{12}(1) \\ a_{21}(1) & a_{22}(1) \end{bmatrix} \begin{bmatrix} X_1(-1) \\ X_2(-1) \end{bmatrix} + \dots$$

$$+ \begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix} \begin{bmatrix} x_1(-n) \\ x_2(-n) \end{bmatrix} + \begin{bmatrix} U_1(0) \\ U_2(0) \end{bmatrix}$$

$$(5.5)\quad \begin{array}{c} X(0) \\ \begin{bmatrix} 0 \\ 1 \end{bmatrix} \end{array} = \begin{bmatrix} a_{11}(1) & a_{12}(1) \\ a_{21}(1) & a_{22}(1) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \dots$$

$$+ \begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$
\text{(5.6)}\quad
\overset{X(1)}{\begin{bmatrix} a_{12}(1) \\ a_{22}(1) \end{bmatrix}}
=
\begin{bmatrix} a_{11}(1) & a_{12}(1) \\ a_{21}(1) & a_{22}(1) \end{bmatrix}
\begin{bmatrix} 0 \\ 1 \end{bmatrix} + \ldots
$$

$$
+ \begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix}
\begin{bmatrix} 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix}
$$

$$
\text{(5.7)}\quad
\overset{X(2)}{\begin{bmatrix} \sum_{i}^{2} a_{1i}(1)a_{i2}(1) + a_{12}(2) \\ \sum_{i}^{2} a_{2i}(1)a_{i2}(1) + a_{22}(2) \end{bmatrix}}
=
\begin{bmatrix} a_{11}(1) & a_{12}(1) \\ a_{21}(1) & a_{22}(1) \end{bmatrix}
\begin{bmatrix} a_{12}(1) \\ a_{22}(1) \end{bmatrix}
$$

$$
+ \begin{bmatrix} a_{11}(2) & a_{12}(2) \\ a_{21}(2) & a_{22}(2) \end{bmatrix}
\begin{bmatrix} 0 \\ 1 \end{bmatrix} + \ldots +
\begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix}
\begin{bmatrix} 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix}
$$

The procedure is continued, iteratively advancing the system through time to determine the value of the impulse responses for additional steps in time beyond the second. Finally, the entire procedure may be repeated using a unit shock for the first rather than the second innovation if the analyst is interested in responses to a shock in the first component of the X vector as well as the second.

The impulse responses derived from the AR representation of the model shown in 5.4 relate directly to the moving average (MA) representation of the model. Equation 5.8 is the MA representation of model 5.4.

$$(5.8)\quad \begin{bmatrix} X_1(0) \\ X_2(0) \end{bmatrix} = \begin{bmatrix} U_1(0) \\ U_2(0) \end{bmatrix} + \begin{bmatrix} b_{11}(1) & b_{21}(1) \\ b_{21}(1) & b_{22}(1) \end{bmatrix} \begin{bmatrix} U_1(-1) \\ U_2(-1) \end{bmatrix}$$

$$+ \begin{bmatrix} b_{11}(2) & b_{12}(2) \\ b_{21}(2) & b_{22}(2) \end{bmatrix} \begin{bmatrix} U_1(-2) \\ U_2(-2) \end{bmatrix} + \ . \ . \ .$$

The result of setting all levels of the X vector and all innovations equal to the mean value of zero except for X(0) and U_2 is shown in equation 5.9. The model is advanced one step in time in equation 5.10.

$$(5.9)\quad \overset{X(0)}{\begin{bmatrix} 0 \\ 1 \end{bmatrix}} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} + \begin{bmatrix} b_{11}(1) & b_{12}(1) \\ b_{21}(1) & b_{22}(1) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \ . \ . \ .$$

$$(5.10)\quad \overset{X(1)}{\begin{bmatrix} b_{12}(1) \\ b_{22}(1) \end{bmatrix}} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \begin{bmatrix} b_{11}(1) & b_{12}(1) \\ b_{21}(1) & b_{22}(1) \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$+ \begin{bmatrix} b_{11}(2) & b_{12}(2) \\ b_{21}(2) & b_{22}(2) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} + \ . \ . \ .$$

The first-step impulse response vectors derived from the AR and MA representations are compared in equation 5.11, and likewise, the second-step impulse response vectors derived from the two representations of the model are compared in equation 5.12. The results of equations 5.11 and 5.12 generalize such that element $b_{ij}(L)$ of the matrix of moving-average coefficients of the L-lagged innovation vector traces the L-step ahead response of series i to a unit shock in series j.

$$(5.11) \qquad \begin{array}{c} X(1) \\ \begin{bmatrix} X_1(1) \\ X_2(1) \end{bmatrix} \end{array} = \begin{bmatrix} a_{12}(1) \\ a_{22}(1) \end{bmatrix} = \begin{bmatrix} b_{12}(1) \\ b_{22}(1) \end{bmatrix}$$

$$(5.12) \qquad \begin{array}{c} X(2) \\ \begin{bmatrix} X_1(2) \\ \\ X_2(2) \end{bmatrix} \end{array} = \begin{bmatrix} \sum_{i}^{2} a_{1i}(1)a_{i2}(1) + a_{12}(2) \\ \\ \sum_{i}^{2} a_{2i}(1)a_{i2}(1) + a_{22}(2) \end{bmatrix} = \begin{bmatrix} b_{12}(2) \\ \\ b_{22}(2) \end{bmatrix}$$

Having developed a strategy for tracing the evolution of the system following a shock to one of the elements of the innovation vector, the form of the shock must be defined carefully. Recall that assumption 5.2 provides for the possible existence of contemporaneous correlation among the elements of the innovation vector. Of fundamental concern in this experiment is the impact of a shock to the federal deficit on the evolution of the other variables in the system. If the element of the innovation vector corresponding to the deficit (U_1) is correlated with other elements of the innovation vector, then the meaning of a shock to the deficit innovation is not clear. That is, a shock to the deficit innovation could arise elsewhere in the system.

Ideally, one wishes to consider only that portion of a given shock arising independently from the remainder of the system. Assuming that none of the elements of the innovation vector are perfectly correlated, only that portion of each innovation which is orthogonal to the other elements in the vector should be included in the analysis. The most common procedure for disentangling the orthogonal portion of the innovation vector, V(t), from U(t) is to apply a Choleski decomposition to the variance-covariance matrix.

The problem at hand is to find a transformation matrix G which satisfies condition 5.13. Since Σ is symmetric and positive definite it can be decomposed according to equation 5.14 where H is a lower

$$(5.13) \quad G\Sigma G' = I$$

$$(5.14) \quad \Sigma = HH'$$

triangular matrix. Note that the matrix H is not unique but will depend in general upon the ordering of the rows of Σ and the X vector. Inspection of equations 5.13 and 5.14 suggest that G should be specified by equation 5.15, a result which is verified in 5.16. The transformed AR representation of model 5.1 is written in equation 5.17. The transformed

$$(5.15)\quad G = H^{-1}$$

$$(5.16)\quad G\Sigma G' = H^{-1}HH'(H^{-1})' = I$$

$$(5.17)\quad G[I-A(L)]\ [X(t)] = G[U(t)] = V(t)$$

or orthogonalized innovation vector V(t) is free of any contemporaneous correlation among its elements. Following Bessler (1984a), the abbreviated model of 5.4 is transformed in 5.18 to show the effects of the transformation on the simulation of the impulse responses. As shown in equations 5.19 and 5.20, a one unit shock in the transformed element V_1 is equivalent to a one-standard deviation shock in the untransformed element U_1.

$$(5.18)\quad \begin{bmatrix} g_{11} & 0 \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} X_1(0) \\ X_2(0) \end{bmatrix} = \begin{bmatrix} g_{11} & 0 \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} a_{11}(1) & a_{12}(1) \\ a_{21}(1) & a_{22}(1) \end{bmatrix} \begin{bmatrix} X_1(-1) \\ X_2(-1) \end{bmatrix}$$

$$+ \; . \; . \; . \; + \begin{bmatrix} g_{11} & 0 \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} a_{11}(n) & a_{12}(n) \\ a_{21}(n) & a_{22}(n) \end{bmatrix} \begin{bmatrix} X_1(-n) \\ X_2(-n) \end{bmatrix} + \begin{bmatrix} V_1(0) \\ V_2(0) \end{bmatrix}$$

$$(5.19)\quad V_1(t) = g_{11}U_1(t)$$

$$(5.20)\quad U_1(t) = g_{11}{}^{-1}V_1(t) = \sigma_{11}{}^{1/2}$$

In addition to removing contemporaneous correlation among the elements of the innovation vector, the procedure of transforming the model by premultiplying by the lower triangular matrix G has another important effect on the model. The transformed model is Wold recursive. A shock emanating from the first equation in the model can be instantaneously reflected in all other variables of the system. A shock to a variable appearing later in the ordering cannot be instantaneously reflected in the values of variables placed ahead of it in the ordering. Only that variable placed last in the ordering can be instantaneously affected by a shock in each of the other variables in the system. Thus, the results of the analysis of the orthogonalized model are order dependent, an artifact of the order-dependent decomposition of the variance-covariance matrix.

The recursive nature of the transformed model suggests that the analyst use outside information in specifying the order of the variables in vector X. Specifically, the variable believed to be least influenced by other variables in the system--the most exogenous variable--should be placed first in the ordering, and the variable believed to be most affected by shocks in the other variables in the system--the most endogenous variable--should appear last in the ordering. The position of each of the remaining variables appearing at intermediate positions in the X vector is chosen according to the same criterion. In this respect the VAR modeling procedure is not entirely free of the imposition of a priori restrictions.

In the problem at hand, the conceptual model of Chapter Four provides a strong case a priori for the ordering chosen in 5.1. That is, shocks to the macropolicy variables, Deficit and M1, affect the real rate of interest, RRate, which in turn affects returns to land, Returns. The real rate of interest and returns to land both play a role in determining Value. Alternative orderings considered are discussed along with the presentation of empirical results in Chapter Six.

The decomposition of forecast error

The concepts underlying the techniques of decomposition of forecast error or variance decomposition are most readily approached using the MA representation of the model. The MA representation of model 5.1 is shown in equation 5.21 where the B_i are 5 x 5 matrices of constants. Recalling the relationship (equation 5.17) between the untransformed innovations and the orthogonalized innovations, 5.22 is the transformed, MA equivalent of 5.1.

$$(5.21)\quad X(t) = U(t) + B_1U(t-1) + B_2U(t-2) + \ldots$$

$$(5.22)\quad X(t) = HV(t) + B_1HV(t-1) + B_2HV(t-2) + \ldots$$

Granger and Newbold (1977) show that the optimal, linear estimator of the h-step ahead forecast of the X vector made at time t, X(t+h), is given by expression 5.23. Expression 5.24 represents the difference between the observed and forecast values of X(t+h) or the error of the h-step ahead forecast. The expression for the forecast error in 5.27 is

$$(5.23)\quad F(t, h) = \sum_{j=0}^{\infty} B_{j+h} HV(t-j)$$

$$(5.24)\quad \varepsilon(t, h) = X(t+h) - F(t, h)$$

derived by substituting 5.22 and 5.23 into 5.24 resulting in equation 5.25, expanding the summation operator of the first term (equation 5.26), and then simplifying. The variance of the forecast error is shown in 5.28.

$$(5.25)\quad \varepsilon(t, h) = \sum_{j=0}^{\infty} B_j HV(t+h-j) - \sum_{j=0}^{\infty} B_{j+h} HV(t-j)$$

$$(5.26)\quad \varepsilon(t, h) = \sum_{j=0}^{h-1} B_j HV(t+h-j) + \sum_{j=0}^{\infty} B_{j+h} HV(t-j) - \sum_{j=0}^{\infty} B_{j+h} HV(t-j)$$

$$(5.27)\quad \varepsilon(t, h) = \sum_{j=0}^{h-1} B_j HV(t+h-j)$$

$$(5.28)\quad \mathrm{Var}[\varepsilon(t, h)] = E[\varepsilon(t, h)\ \varepsilon(t, h)'] = \sum_{j=0}^{h-1} B_j HH'B_j'$$

From equation 5.28, the h step-ahead forecast error variance in series i caused by a shock in series j can be expressed as in 5.29.

$$(5.29) \quad FV(i, j, h) = \frac{\sum_{s=0}^{h-1} [B_{ij}H(s)]^2}{\sum_{s=0}^{h-1} \sum_{j=1}^{m} [B_{ij}H(s)]^2}$$

Intuitively, 5.29 is the ratio of that portion of the variation in series i caused by a shock in series j to the total variation in series i. In this sense the decomposition of forecast error measures the relative importance of a shock in series j in determining the evolution of series i through time. If a variable is entirely exogenous to the other elements of the X vector, that variable's own innovations will explain 100 percent of its forecast error variance at all horizons. Thus, this technique provides a measure of the strength of the causal relationships among the variables in the model over time. Typically in VAR applications proportions of variance explained of less than 10 to 15 percent are not considered significant due to the reflection of the error in the OLS estimates of the VAR model in these simulations (Falk, 1985).

The interpretation of the results of the innovation accounting procedures are most straightforward when little correlation exists among the elements of U. As the degree of correlation among the elements of U declines, the results of the analysis become more robust with respect to changes in the ordering of the elements of the X vector. The extent of the correlation between elements of U can be assessed by comparing the percentage of the first-step variance of a variable explained by its own innovations with that explained by innovations in variables appearing earlier in the causal ordering. If the own, first-step innovations explain most of the variance in the variable, then the innovations of that variable are not highly correlated with the innovations of the variables appearing earlier.

When a high degree of correlation does exist among the innovations in two or more variables, a problem arises in determining which of the variables is the true causative factor in explaining variance in other variables in the system. A resolution to the problem discussed in Falk (1985) and Doan and Litterman (1983) is to place two variables with correlated innovations side by side in the causal ordering and to compare the decomposition of variance from separate models in which the order of the two variables in question is reversed. If most of the explanatory power of the two variables appears to lie in the first of the two variables in the order regardless of which is placed first, no conclusion can be drawn. If, however, one of the variables in question appears to have greater explanatory power than the other when placed second in the causal ordering, that variable is probably the true causative factor. Examples of the use of this technique are provided in the following chapter.

Estimation and lag length determination

To this point in the discussion of the empirical techniques applied in analyzing the model of equations 5.1 through 5.3, the assumption that the elements of A(L) and the lag length n are known has been maintained. In practice, of course, this is not the case. If the lag length were known, however, the elements of A(L) could be estimated. Given the form of the variance-covariance matrix Σ (equation 5.3), Zellner's estimator for seemingly unrelated regression would provide efficient estimates of the elements of A(L). When the independent variables of all of the equations in the system are identical, however, Zellner's estimator is identical to the OLS estimator (Johnston, 1984). Therefore, the elements of A(L) are estimated efficiently using OLS and the elements of Σ are approximated by the sample second moment matrix of the residuals from the OLS regressions.

The problem of determining the appropriate lag length n remains. The test employed here is that suggested by Sims (1980) and reviewed in Falk, Devadoss, and Meyers (1985). The test is based on statistic 5.30 which is asymptotically distributed as a chi-square distribution with q degrees of freedom under the null hypothesis that $A(n_1+1),\ldots,A(n_2) = 0$.

$$(5.30)\quad (T-k)\left(\ln \operatorname{Det} \Sigma_{n_1} - \ln \operatorname{Det} \Sigma_{n_2}\right) \xrightarrow{D} \chi^2(q)$$

where: T is the number of observations,

k is the number of coefficients estimated per equation, and

q is the total number of restrictions imposed.

The procedure followed in this test is to estimate model 5.1 with an assumed lag of order n_2 using OLS. The lag length is then shortened to n_1, and this restricted model is estimated using OLS. Test statistic 5.30 is applied to determine if the restricted model employing the shorter lag length n_1 for all variables is appropriate. The procedure is

Table 5.1. Results of the lag length tests

Lags	k	T-k	Statistic[a]
3	15	35	36.00
4	20	30	31.87
5	25	25	37.69
6	30	20	25.89

[a]Critical values of the chi-square distribution with 25 degrees of freedom are 34.38, 37.65, and 44.31 for the 0.10, 0.05, and 0.01 levels of significance, respectively.

repeated until the most parsimonious representation of 5.1 which adequately captures the information in the data is determined.

The results of the lag-length testing procedure conducted for lag orders of two through six are presented in Table 5.1. Using series of annual data from 1936 through 1985 provides a total T of 50 oberservations.[1] The number of parameters k estimated per equation is equal to the lag length considered times the number of equations in the model. With five equations, the total number of restrictions q tested in each line of Table 5.1 is 25, a zero restriction for the coefficient of one lagged value of each of five variables in each of five equations.

Lags of order greater than six were not considered because the available data series were not of sufficient length to support the estimation of additional coefficients. In fact, model 5.1 specified with a lag length of six was moderately explosive. The data of Table 5.1 indicate that the autoregression matrix at lag six does not differ from zero at generally accepted levels of statistical significance. The calculated chi-square statistic at lag five, however, exceeds the critical value at the 0.05 significance level. Based on the series of likelihood-ratio tests presented in Table 5.1, a lag length of five was chosen for the specification of the VAR model of equations 5.1 through 5.3.

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[1]The observation for 1929 is lost in calculating the inflation rate, the real rate of interest, and percentage changes in Returns and Value. Observations for 1930 to 1935 are used as lagged values.

CHAPTER SIX: RESULTS OF THE EMPIRICAL ANALYSES

The results of the empirical tests of the validity of the hypotheses developed in the conceptual model of Chapter Four and clarified in the first section of Chapter Five are presented in this chapter. These results consist of the data from the innovation accounting procedures introduced in the concluding sections of Chapter Five and applied to the VAR model of equations 5.1 through 5.3. The RATS package of computer software developed by Doan and Litterman (1983) was used throughout the empirical analysis described in this chapter. The results presented in the first section of Chapter Six are those derived from the estimation of the VAR model specified with a lag length of five years and estimated using the full set of data available for years 1930 through 1985. The second section of the chapter presents similar results derived from the VAR model of system 5.1 specified with a shortened lag length of only four years and estimated over the post World War II data period. In each section the results of simulations of models derived from alternative orderings of the variables in the X vector of system 5.1 are discussed to ensure appropriate interpretation of the innovation accounting data.

Estimation of the VAR Model Over the Entire Data Period

In this section, results from the innovation accounting procedures applied to model 5.1 following estimation of the model over the entire sample period from 1935 (with lags extending to 1930) to 1985 are presented. The responses of the variables of the X vector of system 5.1 to one-time shocks in other variables in the system, the impulse responses, are compared with the hypothesized responses of these variables summarized in the first section of Chapter Five. Tables providing the decomposition of variance of each of the five variables of the X vector follow the presentation of the impulse responses and provide a measure of the relative significance of the response in each of the variables to a shock in another variable.

Impulse responses

Plots of impulse responses of the variables of the X vector are shown in Figures 6.1 through 6.9. The data from which these plots were drawn are found in Appendix C. Each of these nine plots displays the cyclical nature of the impulse responses typically found in VAR applications. Also evident in each figure is the fact that the magnitude of the h-step ahead response to a one-standard deviation shock in another variable occurring in period one trends towards zero as the time index h advances, a fact which confirms the stationarity of the X vector. Although the responses were calculated and plotted through step or year 30 as a check on the stationarity of the model, little credence is given to responses beyond the initial several steps.

Figures 6.1 through 6.3 are plots of the response of the real rate of interest (RRate), the percentage change in returns to land (Returns), and the percentage change in land value (Value), to a one-standard deviation shock in the federal deficit (Deficit). The short-run response of RRate to a Deficit shock (Figure 6.1) is positive, a response which is in agreement with the corresponding hypothesis drawn from the conceptual

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
 1  +                 +  D                           +
 2  +                 +                             D+
 3  +                 +       D                      +
 4  D                 +                              +
 5  +                 +      D                       +
 6  +                 +                          D   +
 7  +                 +                              D
 8  +                 +    D                         +
 9  +     D           +                              +
10  +                 +D                             +
11  +                 +     D                        +
12  +                 +   D                          +
13  +             D   +                              +
14  +           D     +                              +
15  +                 D                              +
16  +                 + D                            +
17  +                 D                              +
18  +                 + D                            +
19  +                 + D                            +
20  +                 +    D                         +
21  +                 +   D                          +
22  +                 +  D                           +
23  +                 +   D                          +
24  +                 + D                            +
25  +                 D                              +
26  +               D +                              +
27  +             D   +                              +
28  +             D   +                              +
29  +             D   +                              +
30  +             D   +                              +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                   -  0  +
```

Figure 6.1. Plot of response of RRate to a one-standard deviation shock in Deficit

```
Step
     +++++++++++++++++++++++++++++++++++++++++++++++++++
  1  +                            D  +                 +
  2  +         D                     +                 +
  3  +                    D          +                 +
  4  D                               +                 +
  5  +                          D    +                 +
  6  +              D                +                 +
  7  +                               +    D            +
  8  +                               +       D         +
  9  +                               +     D           +
 10  +                               +                 D
 11  +                               +             D   +
 12  +                               + D               +
 13  +                               +     D           +
 14  +                              D+                 +
 15  +                               + D               +
 16  +                               +D                +
 17  +                          D    +                 +
 18  +                              D+                 +
 19  +                          D    +                 +
 20  +                            D  +                 +
 21  +                            D  +                 +
 22  +                           D   +                 +
 23  +                               D                 +
 24  +                               + D               +
 25  +                               + D               +
 26  +                               +     D           +
 27  +                               +    D            +
 28  +                               +     D           +
 29  +                               +   D             +
 30  +                               + D               +
     +++++++++++++++++++++++++++++++++++++++++++++++++++
                                  -  0  +
```

Figure 6.2. Plot of response of Returns to a one-standard deviation shock in Deficit

```
Step
    +++++++++++++++++++++++++++++++++++++++++++++++++++
  1 +          D                    +                 +
  2 +      D                        +                 +
  3 +             D                 +                 +
  4 D                               +                 +
  5 +     D                         +                 +
  6 +                 D             +                 +
  7 +                               D                 +
  8 +                               +D                +
  9 +                               +            D    +
 10 +                               +                D+
 11 +                               +                 D
 12 +                               +           D     +
 13 +                               +            D    +
 14 +                               +    D            +
 15 +                               +   D             +
 16 +                              D+                 +
 17 +                         D     +                 +
 18 +                      D        +                 +
 19 +                      D        +                 +
 20 +                      D        +                 +
 21 +                       D       +                 +
 22 +                         D     +                 +
 23 +                             D +                 +
 24 +                               + D               +
 25 +                               +   D             +
 26 +                               +       D         +
 27 +                               +       D         +
 28 +                               +        D        +
 29 +                               +      D          +
 30 +                               +    D            +
    +++++++++++++++++++++++++++++++++++++++++++++++++++
                                 -  0  +
```

Figure 6.3. Plot of response of Value to a one-standard deviation shock in Deficit

model. Although the response in RRate is very strongly positive at step two, the positive response is short-lived, and by step four the response is strongly negative as the response series cycles toward zero.

The response of Returns to a shock in Deficit (Figure 6.2) is strongly negative and well-sustained through the initial six steps following the shock before cycling into the positive region in a gradual spiral toward zero. The direction of the Returns response to a Deficit shock is in agreement with the hypothesis of the second channel of macroeconomic policy outlined in Chapter Five. The pattern of the Value response through time to the initial Deficit shock (Figure 6.3) is nearly identical to that of the Returns response. The initial Value response is strongly negative, reaches its lowest most point at step four, and remains in the negative region through step six. The negative Value response to a Deficit shock is in agreement with the hypotheses developed in the conceptual model and summarized in Chapter Five.

Figures 6.4 through 6.6 summarize the evolution of the variables RRate, Returns, and Deficit, respectively, following an initial one-standard deviation shock in the money supply variable, M1, the annual percentage change in the M1 money supply. Figure 6.4 leaves little doubt that the response of RRate to an M1 shock is strongly negative. Indeed, the negative response is sustained through the thirteenth step following the initial M1 shock. The Returns response to the M1 shock (Figure 6.5) is positive, peaking at step two and remaining positive through step four. The positive Value response (Figure 6.6) also peaks at step two, but the initial positive response is somewhat less well sustained than

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
  1 M                                         +      +
  2 +     M                                   +      +
  3 +                           M             +      +
  4 +                            M            +      +
  5 +                               M         +      +
  6 +                  M                      +      +
  7 +                 M                       +      +
  8 +                       M                 +      +
  9 +                               M         +      +
 10 +                                 M       +      +
 11 +                                   M     +      +
 12 +                                    M    +      +
 13 +                                       M +      +
 14 +                                         +M     +
 15 +                                         +    M +
 16 +                                         +      M
 17 +                                         +      M
 18 +                                         +      M
 19 +                                         +      M
 20 +                                         +      M
 21 +                                         +     M+
 22 +                                         +     M+
 23 +                                         +   M  +
 24 +                                         +   M  +
 25 +                                         +  M   +
 26 +                                         + M    +
 27 +                                         +M     +
 28 +                                         +M     +
 29 +                                         M      +
 30 +                                         M      +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                                           -  0  +
```

Figure 6.4. Plot of response of RRate to a one-standard deviation shock in M1

```
Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
   1 +              +           M                     +
   2 +              +                                 M
   3 +              +                M                +
   4 +              +     M                           +
   5 +   M          +                                 +
   6 +       M      +                                 +
   7 +              M                                 +
   8 +     M        +                                 +
   9 +              +          M                      +
  10 +        M     +                                 +
  11 +           M  +                                 +
  12 +        M     +                                 +
  13 +            M +                                 +
  14 M              +                                 +
  15 +      M       +                                 +
  16 + M            +                                 +
  17 +       M      +                                 +
  18 +       M      +                                 +
  19 +             M+                                 +
  20 +             M+                                 +
  21 +              +M                                +
  22 +              + M                               +
  23 +              +  M                              +
  24 +              +  M                              +
  25 +              +   M                             +
  26 +              +   M                             +
  27 +              +  M                              +
  28 +              +   M                             +
  29 +              + M                               +
  30 +              + M                               +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
                 -  0  +
```

Figure 6.5. Plot of response of Return to a one-standard deviation shock in M1

```
Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
  1  +            + M                                 +
  2  +            +                                   M
  3  +            M                                   +
  4  +            +           M                       +
  5  +            +     M                             +
  6  +            +      M                            +
  7  +         M  +                                   +
  8  +            +       M                           +
  9  +            +  M                                +
 10  +        M   +                                   +
 11  +         M  +                                   +
 12  +         M  +                                   +
 13  +    M       +                                   +
 14  + M          +                                   +
 15  +   M        +                                   +
 16  M            +                                   +
 17  +   M        +                                   +
 18  +    M       +                                   +
 19  +        M   +                                   +
 20  +        M   +                                   +
 21  +            M                                   +
 22  +            +M                                  +
 23  +            +  M                                +
 24  +            +  M                                +
 25  +            +    M                              +
 26  +            +  M                                +
 27  +            +   M                               +
 28  +            +  M                                +
 29  +            + M                                 +
 30  +            +M                                  +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
               -  0  +
```

Figure 6.6. Plot of response of Value to a one-standard deviation shock in M1

that of Returns. At step three the Value response cycles to a value slightly less than zero (see Table C.2, Appendix C). The strongly negative response of RRate and the positive responses of Returns and Value to an M1 shock support the corresponding hypotheses of the previous chapter.

The responses of the variables Returns and Value to a one-standard deviation shock in RRate are displayed in Figures 6.7 and 6.8, respectively. Exactly contrary to the hypotheses drawn from the conceptual model of Chapter Four, the initial response of both Returns and Value to the RRate shock is positive. In both cases, however, the response through the initial steps following the shock is very erratic, cycling from the strongly positive response at step one to a strongly negative response at step three. The erratic nature of the responses of Returns and Value to the RRate shock is difficult to interpret, but suggests that these responses may not have a great deal of meaning, a suggestion which is verified in the analyses of the decomposition of variance of Returns and Value in the following section.

The final figure of this series, Figure 6.9, shows the evolution of the Value variable following a Returns shock. The strongly positive and well-sustained response of Value to the Returns shock is in agreement with the income-capitalization models reviewed in Chapter Two and tends to verify the validity of the VAR modeling techniques applied in this chapter. Indeed, results contrary to those reported in Figure 6.9 would be very difficult to interpret.

```
Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
  1  +                             +                  I
  2  +                             +I                 +
  3  I                             +                  +
  4  +                         I   +                  +
  5  +                             +      I           +
  6  +                             +                I +
  7  +                   I         +                  +
  8  +                             +      I           +
  9  +                             +             I    +
 10  +                             +    I             +
 11  +                             +      I           +
 12  +                             +I                 +
 13  +                       I     +                  +
 14  +                             +  I               +
 15  +                          I  +                  +
 16  +                           I +                  +
 17  +                             + I                +
 18  +                          I  +                  +
 19  +                            I+                  +
 20  +                        I    +                  +
 21  +                          I  +                  +
 22  +                           I +                  +
 23  +                          I  +                  +
 24  +                            I+                  +
 25  +                             +I                 +
 26  +                             I                  +
 27  +                             + I                +
 28  +                             I                  +
 29  +                             +I                 +
 30  +                             I                  +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
                                - 0 +
```

Figure 6.7. Plot of response of Returns to a one-standard deviation shock in RRate

```
Step
      ++++++++++++++++++++++++++++++++++++++++++++++++++
   1  +                +                               I
   2  +      I         +                               +
   3  I                +                               +
   4  +                +     I                         +
   5  +             I  +                               +
   6  +            I   +                               +
   7  +                +  I                            +
   8  +                +       I                       +
   9  +                +   I                           +
  10  +                +             I                 +
  11  +                +         I                     +
  12  +                +   I                           +
  13  +                +I                              +
  14  +                +     I                         +
  15  +              I +                               +
  16  +              I +                               +
  17  +               I+                               +
  18  +            I   +                               +
  19  +          I     +                               +
  20  +           I    +                               +
  21  +           I    +                               +
  22  +            I   +                               +
  23  +             I  +                               +
  24  +               I+                               +
  25  +                I                               +
  26  +                +I                              +
  27  +                +  I                            +
  28  +                + I                             +
  29  +                + I                             +
  30  +                +I                              +
      ++++++++++++++++++++++++++++++++++++++++++++++++++
                    -  0  +
```

Figure 6.8. Plot of response of Value to a one-standard deviation shock in RRate

```
 Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
  1  +         +                                      R
  2  +         +                R                     +
  3  +         +                R                     +
  4  +         +              R                       +
  5  +         +      R                               +
  6  +        R+                                      +
  7  +      R  +                                      +
  8  +   R     +                                      +
  9  +  R      +                                      +
 10  +R        +                                      +
 11  + R       +                                      +
 12  R         +                                      +
 13  +R        +                                      +
 14  +    R    +                                      +
 15  +      R  +                                      +
 16  +         +R                                     +
 17  +         +    R                                 +
 18  +         +      R                               +
 19  +         +       R                              +
 20  +         +       R                              +
 21  +         +     R                                +
 22  +         +   R                                  +
 23  +         +R                                     +
 24  +        R+                                      +
 25  +      R  +                                      +
 26  +    R    +                                      +
 27  +    R    +                                      +
 28  +    R    +                                      +
 29  +     R   +                                      +
 30  +      R  +                                      +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
            -  0  +
```

Figure 6.9. Plot of response of Value to a one-standard deviation shock in Returns

Decomposition of forecast error variance

Tables 6.1 through 6.5 summarize the decomposition of the total forecast error variance of each of the five variables of the X vector of system 5.1 into the proportions which are attributable to innovations in each of the five variables. These data reveal the relative importance of shocks in each of the variables in the X vector in explaining the variation in each of the other variables in the vector as discussed in the preceding section. In this sense, the decomposition of variance tables provide a measure of the causal relationships among the variables of the X vector. These data combined with the impulse response data of the previous section complete the information set available for testing the validity of the hypotheses drawn from the conceptual, portfolio-balance model of Chapter Four.

Note that even though the model simulations were completed for 30 forward steps as shown in the plots of the impulse responses in Figures 6.1 through 6.9, the decomposition of variance data of Tables 6.1 through 6.5 have been truncated at the fifteenth step. Inspection of the data revealed that the forecast error variances had generally converged by the fifteenth step so that little information of value was lost in deleting the data after step 15. Furthermore, no inferences are made from the data beyond the initial several steps.

Tables of the decomposition of variance of the variables Deficit (Table 6.1) and M1 (Table 6.2) are provided primarily as a means of verifying the assumed exogeneity of these two macropolicy variables with respect to the other variables in the model, an assumption which led to

Table 6.1. Decomposition of the forecast error variance of Deficit

Step	Variance in Deficit attributed to innovations in: Deficit	M1	RRate	Returns	Value
	Percent				
1	100.000000	0.0	0.0	0.0	0.0
2	75.911684	0.243710	3.572052	8.272841	11.999714
3	72.841652	0.592339	3.784751	8.411055	14.370203
4	67.008403	0.703570	7.201089	11.856061	13.230876
5	64.024352	0.955826	7.091239	14.303937	13.624646
6	63.793015	0.944308	6.276047	17.122954	11.863676
7	62.783430	1.345122	7.393173	16.856057	11.622218
8	63.068859	1.362106	7.333896	16.712115	11.523025
9	62.488503	1.369101	7.631686	16.608001	11.902709
10	60.059400	1.529888	7.453697	19.224843	11.732172
11	58.430043	1.956518	7.439194	19.692440	12.481805
12	57.371031	2.000983	7.420099	20.306696	12.901191
13	58.011252	2.002032	7.087098	20.075509	12.824109
14	57.689761	2.146089	7.114343	19.840262	13.209545
15	57.821787	2.201286	7.078560	19.741492	13.156875

Table 6.2. Decomposition of the forecast error variance of M1

Step	Variance in M1 attributed to innovations in: Deficit	M1	RRate	Returns	Value
	-------------------------Percent-------------------------				
1	1.766886	98.233114	0.0	0.0	0.0
2	1.329887	89.919469	5.162073	3.574945	0.013626
3	2.831212	86.480134	7.010252	3.249742	0.428660
4	2.941751	85.169843	8.020044	3.261901	0.606461
5	19.347726	68.424908	8.527028	3.142337	0.558002
6	21.198298	66.252934	8.354667	3.495231	0.698871
7	23.709632	63.869409	7.968229	3.540549	0.912182
8	23.720160	63.303924	7.988910	4.022326	0.964681
9	24.137036	62.060234	8.246207	4.601639	0.954884
10	24.267538	60.857767	8.804023	4.971433	1.099239
11	24.794447	60.289503	8.764265	5.060320	1.091464
12	24.457598	59.588131	8.683896	5.743350	1.527025
13	24.123072	59.269674	8.710387	6.180470	1.716398
14	24.260070	58.506334	8.698440	6.507362	2.027795
15	24.057945	58.397950	8.770428	6.536186	2.237491

the placing of these two variables in the first two positions in the causal ordering of the X vector. By virtue of the procedure used to orthogonalize the innovation vector, 100 percent of the step-one variation in the first variable of the X vector, Deficit, is attributed to its own innovations (Table 6.1). The percentage of the variation in Deficit attributable to its own innovations falls rather sharply at step two, but declines gradually thereafter. At step 15 approximately 58 percent of the variation in Deficit is explained by its own innovations.

Reference to the last two columns of Table 6.1 indicates that innovations in Value and Returns explain percentages of the variation in Deficit which are at the threshold of significance beginning at steps two and four, respectively. Scenarios in which variation in Returns and Value affect Deficit through changes in tax revenues are conceivable, but the evidence for feedback relationships from the variables Returns and Value to Deficit provided in Table 6.1 is not strong. Moreover, the discussion of such reactions is sufficiently beyond the scope of the hypotheses set out in Chapter Five to warrant no further comment in this study. The fact that the major portion of the variation in the variable Deficit is explained by its own innovations throughout the forecast horizon is taken as sufficient evidence to verify its exogeneity and justify its position in the causal ordering of the X vector.

As was the case for the variable Deficit, the major portion of the variance in M1 is attributable to its own innovations throughout the simulation horizon. The proportion of the variation in M1 attributable to its own innovations is 98 percent at step one and declines to 58 percent at step 15. Innovations in Deficit appear to explain a significant portion of the variation in M1 beginning at step five. The data of Table C.1 (Appendix C) indicate that the response of M1 to a Deficit shock is positive at steps one through four and negative for a prolonged period beginning at step five, the step at which the proportion of the variation in M1 explained by innovations in Deficit becomes significant.

These data suggest that the causal relationship between Deficit and M1 is weak through step four, but that a Deficit shock leads, by about four years, a tightening of the money supply. The evidence of this effect is not strong nor is this conclusion important in the consideration of the hypotheses presented in Chapter Five. Of greater relevance to this study is the observation that the greatest share of variability in M1 is explained by its own innovations throughout the forecast horizon, a fact which justifies the appearance of M1 early in the causal ordering of the X vector.

Unlike the decomposition of variance data reviewed for Deficit and M1, the data of Table 6.3 insist that RRate is not an exogenous variable in system 5.1. Only 62 percent of the forecast error variance in RRate is explained by its own innovations at step one, a percentage which declines to 26 percent at step 15. Innovations in M1 explain from 34 to 40 percent of the variation in RRate at all horizons, and are nearly as important as innovations in RRate in explaining variation in RRate. Innovations in Deficit explain a marginally significant portion of the variation in RRate with a lag of one year. Clearly, the causal relationship between Deficit and RRate is much weaker than that existing between

Table 6.3. Decomposition of the forecast error variance of RRate

Step	Variance in RRate attributed to innovations in: Deficit	M1	RRate	Returns	Value
			Percent		
1	0.200406	38.102227	61.697367	0.0	0.0
2	12.261855	39.722621	47.207427	0.091139	0.716958
3	11.012127	35.838193	40.805960	4.637318	7.706401
4	12.948026	32.994312	37.045100	7.835821	9.176740
5	13.037537	32.953048	36.369964	8.432941	9.206510
6	17.921545	33.489677	32.609439	7.631622	8.347717
7	23.014946	33.669542	28.910656	6.836448	7.568407
8	22.606833	35.144215	28.150163	6.655544	7.443244
9	23.265224	35.167060	27.649657	6.557959	7.360100
10	22.934523	35.165299	27.521731	6.501527	7.876920
11	22.871497	35.004599	27.248405	6.417463	8.458037
12	22.746341	34.883925	27.068684	6.441329	8.859721
13	22.591762	34.538681	26.784951	6.733334	9.351272
14	22.586271	34.114282	26.462722	7.058737	9.777989
15	22.402604	33.968625	26.379962	7.110344	10.138466

M1 and RRate as shown by that fact that the proportion of the variation in RRate explained by Deficit is approximately one-third of that explained by innovations in M1. These data taken together with the impulse response data of Figures 6.1 and 6.4 lend additional support to the hypotheses concerning the effects of macroeconomic policy on the real rate of interest derived in the previous two chapters.

The data of greatest interest to this investigation, the decomposition of variance of the variables Returns and Value, are provided in Tables 6.4 and 6.5. The data of Table 6.4 indicate that innovations in Returns itself explain the greatest proportion of variation in Returns at all forecast horizons. Of greater significance is the observation that the only variable, aside from Returns itself, which explains a significant proportion of the variability in Returns is Deficit. The percentage of the variation in Returns explained by innovations in Deficit grows from a marginally significant 11 percent at steps two and three to 25 percent at step four. These data, when combined with the observed negative response of Returns to a Deficit shock at steps one through six in Figure 6.2, provide evidence of a significant, negative, causal relationship between Deficit and Returns. More specifically, these simulations suggest that a shock in Deficit is followed by a significant decline in Returns with a lag of approximately three years, an observation consistent with the second channel of macroeconomic policy outlined in Chapter Five.

The anamoly of the initially positive but erratic association of RRate with Returns identified in Figure 6.7 is resolved in part by the

Table 6.4. Decomposition of the forecast error variance of Returns

Step	Variance in Returns attributed to innovations in: Deficit	M1	RRate	Returns	Value
	Percent				
1	0.421762	0.817283	2.774386	95.986570	0.0
2	10.571354	5.469229	2.021046	74.446799	7.491573
3	11.474655	5.718766	5.849749	69.198782	7.758048
4	24.631762	4.815035	4.892869	57.421042	8.239292
5	24.296608	5.058622	4.949923	56.408220	9.286627
6	27.309125	4.913301	5.672072	53.052327	9.053174
7	26.353413	4.692999	5.746572	53.844671	9.362346
8	26.605469	4.850282	5.804878	53.457763	9.281609
9	26.163678	4.975432	6.239835	51.764503	10.856551
10	28.574503	4.817019	6.004174	49.388414	11.215890
11	29.580602	4.666398	5.935341	47.583616	12.234044
12	29.290576	4.716792	5.882635	47.249456	12.860541
13	29.148654	4.662402	5.870690	47.252600	13.065654
14	28.953699	5.162904	5.855701	46.985302	13.042394
15	28.813806	5.293814	5.837649	47.078745	12.975987

Table 6.5. Decomposition of the forecast error variance of Value

Step	Variance in Value attributed to innovations in: Deficit	M1	RRate	Returns	Value
			Percent		
1	11.662148	0.022073	6.545266	60.693221	21.077292
2	19.416523	8.186695	4.741009	48.225680	19.430093
3	20.789797	6.815410	4.902835	46.675512	20.816445
4	28.425626	5.815012	3.893231	39.880671	21.985460
5	32.749319	5.328944	3.504470	36.553905	21.863362
6	33.871436	5.389424	3.457306	35.720444	21.561391
7	33.797435	5.418031	3.471343	35.790483	21.522708
8	33.388825	5.562583	3.592041	35.916996	21.539554
9	33.358121	5.281572	3.435212	34.700747	23.224349
10	33.917248	4.990594	3.649478	33.657687	23.784993
11	34.573878	4.686134	3.604747	32.315835	24.819406
12	34.125285	4.504118	3.480065	32.019843	25.870689
13	34.191674	4.516677	3.346710	31.638652	26.306287
14	33.990592	4.805781	3.391935	31.541355	26.270337
15	33.919316	4.978598	3.380510	31.495199	26.226377

decomposition of variance data of Table 6.4. The strange response of Returns to a shock in RRate is simply not a significant source of variation in Returns relative to its responses to other variables in the model, notably Deficit. Indeed, innovations in RRate explain less than six percent of the variation in Returns at all forecast horizons.

Although the decomposition of variance data for Returns invalidate the evidence of Figure 6.7 which would otherwise tend to refute the hypothesis of a negative causal association between RRate and Returns, these data provide no support for the hypothesis either. Moreover, the hypotheses of Chapter Five suggest that the negative impact of a Deficit shock are transmitted to Returns through RRate. Support for the hypothesis of a negative, causal relationship running from Deficit to Returns has been found, but no support for the hypothesized transfer of the shock through RRate is apparent in the data. This important anamoly must be set aside for now, but it will reappear and be addressed in greater detail before the discussion of the empirical analyses concludes.

Only 20 to 22 percent of the variation in Value is explained by its own innovations as shown in the last column of Table 6.5. During the initial several forecast steps, the greatest share of variation in Value is explained by innovations in Returns. Recalling that the response of Value to a Returns shock is positive in steps one through five of Figure 6.9, these data are reassuring in view of the discussion of the income capitalization models of Chapter Two. Of greater interest to this study, however, is the substantial proportion of Value variation explained by innovations in Deficit. A marginally significant 12 percent of the variation in Value is explained by Deficit innovations at step one, and the percentage of the Value variation explained by innovations in Deficit grows rapidly to 34 percent at step six. In fact, the proportion of the variation in Value explained by Deficit is 40 percent as large as that explained by Returns at step two and equal to that explained by Returns at step six. Along with the impulse response data of Figure 6.3, these data support the hypothesis of a negative, causal relationship running from Deficit to Value as derived in the conceptual model of Chapter Four and restated in Chapter Five.

As was the case for the variable Returns, the decomposition of variance for Value indicates that the erratic response of Value to a RRate shock noted in Figure 6.8 is insignificant relative to the response of Value to a Deficit shock. The observation that innovations in RRate play an insignificant role in explaining variation in Value leaves a missing link in the transmission of a Deficit shock to a decline in Value, another manifestation of the anomaly discovered in the analysis of the decomposition of variance of Returns.

Analysis of alternative orderings

Recall from the review of VAR econometrics presented in Chapter Five that the results of the techniques of innovation accounting are dependent on the ordering of the five variables in the X vector in equation 5.1 due to the use of the Choleski decomposition procedure to orthogonalize the innovation vector. The degree to which the results are affected by the ordering of the variables is directly associated with the strength of the correlation among the innovations in the innovation vector U. In the extreme case in which the variance-covariance matrix Σ of the innovation vector is the identity matrix, the results from the innovation accounting procedures are unaffected by the ordering of the variables in vector X.

In the more general case in which some degree of correlation does exist among the innovations of the VAR system, interpretation of the results of the innovation accounting procedures is somewhat more difficult. Specifically, the determination of which of two "exogenous" variables with correlated innovations is most responsible for the variation in an "endogenous" variable must be made carefully. As outlined in the previous chapter, alternative orderings of the variables of the X vector are an aid in identifying the true causative factor in such a case.

The only evidence in the foregoing analysis of significant correlation among the innovations of the variables of the X vector of system 5.1 is found in Table 6.3, the decomposition of variance of the variable RRate. At step one, nearly 40 percent of the variabililty in RRate is explained by innovations in M1, evidence of significant correlation among the innovations of these two series. This observation suggests that the poor performance of RRate in explaining variability in Returns and Value could be due to the location of RRate after M1 in the causal ordering of the X vector.

As a test of this hypothesis, RRate was shifted ahead of M1 in the causal ordering prior to simulation of the VAR. The decomposition of variance for Returns and Value under this alternative ordering are shown in Tables 6.6 and 6.7, respectively. The total variation in Returns and Value explained by innovations in M1 and RRate is approximately seven to 12 percent, proportions which are, of course, independent of the order of M1 and RRate. At best, little improvement in the explanatory power of RRate could be expected by the change in order, and in fact the results reported in Tables 6.6 and 6.7 are inconsequential. The data offer no support for the claim that the appearance of RRate after M1 in the X vector is responsible for the insignificant portion of the variability in Returns and Value explained by innovations in RRate.

Several additional causal orderings of the variables of the X vector, one of which placed RRate first in the order followed by Deficit, M1, Returns, and Value, were considered. The proportions of variation in Returns and Value explained by RRate, Deficit, and M1 in these alternative orderings were changed only negligibly from that reported in the data of Tables 6.6 and 6.7.

In summary, the results of the simulations of the five-variable VAR estimated over the period 1935 through 1985 insist that Deficit has a significant negative, causal association with both Returns and Value and that Returns has a significant positive, causal association with Value. In addition Deficit and M1 each have a significant causal association with RRate, a Deficit shock driving RRate higher and an M1 shock driving RRate lower. All of these findings are in support of the hypotheses

Table 6.6. Decomposition of the forecast error variance of Returns

Step	Deficit	RRate	M1	Returns	Value
	Variance in Returns attributed to innovations in:				
	Percent				
1	0.421762	0.564070	3.027598	95.986570	0.0
2	10.571354	2.128949	5.361325	74.446799	7.491573
3	11.474655	6.700093	4.868421	69.198782	7.758048
4	24.631762	5.671701	4.036203	57.421042	8.239292
5	24.296608	6.042929	3.965616	56.408220	9.286627
6	27.309125	6.761114	3.824259	53.052327	9.053174
7	26.353413	6.659127	3.780443	53.844671	9.362346
8	26.605469	6.920001	3.735158	53.457763	9.281609
9	26.163678	6.781587	4.433680	51.764503	10.856551
10	28.574503	6.603408	4.217785	49.388414	11.215890
11	29.580602	6.525951	4.075788	47.583616	12.234044
12	29.290576	6.530363	4.069063	47.249456	12.860541
13	29.148654	6.449882	4.083210	47.252600	13.065654
14	28.953699	6.747301	4.271303	46.985302	13.042394
15	28.813806	6.726420	4.405043	47.078745	12.975987

Table 6.7. Decomposition of the forecast error variance of Value

Step	Variance in Value attributed to innovations in: Deficit	RRate	M1	Returns	Value
	-------------------------	-------------------------	Percent	-------------------------	-------------------------
1	11.662148	3.685468	2.881871	60.693221	21.077292
2	19.416523	7.461041	5.466663	48.225680	19.430093
3	20.789797	6.788289	4.929956	46.675512	20.816445
4	28.425626	5.271090	4.437153	39.880671	21.985460
5	32.749319	4.815395	4.018019	36.553905	21.863362
6	33.871436	4.873918	3.972812	35.720444	21.561391
7	33.797435	4.921173	3.968200	35.790483	21.522708
8	33.388825	4.860561	4.294063	35.916996	21.539554
9	33.358121	4.600671	4.116113	34.700747	23.224349
10	33.917248	4.720572	3.919499	33.657687	23.784993
11	34.573878	4.599566	3.691315	32.315835	24.819406
12	34.125285	4.460667	3.523517	32.019843	25.870689
13	34.191674	4.391838	3.471549	31.638652	26.306287
14	33.990592	4.684756	3.512960	31.541355	26.270337
15	33.919316	4.711846	3.647262	31.495199	26.226377

developed in earlier chapters. Evidence of a causal association between M1 and Returns or Value or between RRate and Returns or Value is not apparent in these data, however. Although the lack of evidence in support of hypotheses regarding RRate as the link between macroeconomic policy and Returns and Value does not necessarily refute those hypotheses, it does motivate the additional modeling effort discussed in the following section.

Estimation Over the Post-War Data Period

The results of the innovation accounting procedures described in the foregoing section must be interpreted as reflections of regularities which exist in the data during the entire period over which the VAR model is estimated, the period--with lags included--from 1930 through 1985. As mentioned earlier, this period includes not only the depression years of the 1930s and the war years of the 1940s but also five and one half decades of structural changes in the economy.

Especially interesting in this regard is the marked change in the behavior of RRate over the estimation period (see Figure 1.3). RRate was extremely volatile during the period prior to the early 1950s, reaching a high of approximately 18 percent in 1932 near the nadir of the depression of that decade and a low of approximately negative eight percent early in the war years of the 1940s. Two decades characterized by stability of the RRate series began in 1952, and the volatility which returned to the series in the 1970s and 1980s was not as extreme as that of the pre-war period.

These observations on the behavior of the RRate series suggest that estimation of system 5.1 over the post-war period might provide results at least as meaningful as those discussed above. Indeed, estimation of the model over the shorter time period could lead to the discovery of regularities in these data which might more adequately explain the extraordinary developments which have occurred in the land market during the past fifteen years.

The major obstacle encountered in applying the VAR of equation 5.1 to the shortened, post-war data period is the fact that only 40 observations are available for the estimation of 25 variables per equation in the five-variable, five-lag model. The full, five-year-lag model of system 5.1 and an identical version of 5.1 with the lag length shortened to four years were estimated over the post-war period, and the results of the innovation accounting procedures applied to the two models were compared. Impulse response and variance decomposition data from these two versions of the post-war VAR were generally consistent with one another. Impulse responses from the four-lag version of 5.1 were well-behaved (see Figures 6.10 through 6.18), but those from the five-lag version of the model appeared moderately explosive. The calculated value of Sims' lag-length test statistic for the five-lag model is 26.86, a value which does not fall in the critical region of the chi-square distribution with 25 degree of freedom at generally accepted levels of statistical significance (see Table 5.1). These findings suggest that the four-lag model is an adequate, nonexplosive representation of model 5.1. The results presented in this section are those derived from the innovation accounting procedures applied to the four-lag version of system 5.1 estimated over the period 1946 (initial lags extending to 1942) through 1985.

Impulse responses

Impulse response plots shown in Figures 6.10 through 6.18 are the post-war model analogs of the impulse response plots derived from the full-period estimation presented in Figures 6.1 through 6.9. The impulse response data from which Figures 6.10 through 6.18 were drawn are found in Appendix D. A brief summary of the data of Figures 6.10 through 6.18 is presented in the following paragraph. Additional reference to the impulse response plots of this subsection is found in the discussion of the decomposition of variance data in the following subsection.

The post-war simulations show that a Deficit shock results in a positive RRate response through step three (Figure 6.10), a negative Returns response through step six following a positive response in step one (Figure 6.11), and a negative Value response sustained through step six (Figure 6.12). The response of RRate to an M1 shock is strongly negative and sustained through step eleven (Figure 6.13). The Returns and Value responses to the M1 shock are more erratic, however. The Returns response is negative at step one and positive at steps two through ten (Figure 6.14), and the Value response alternates between the negative and positive regions in steps one through four (Figure 6.15). The responses of Value and Returns to a RRate shock are nearly identical,

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
  1 +                 +                        D     +
  2 +                 +                              D
  3 +                 +            D                 +
  4 D                 +                              +
  5 + D               +                              +
  6 +                 +       D                      +
  7 +                 +                      D       +
  8 +                 +   D                          +
  9 +             D   +                              +
 10 +            D    +                              +
 11 +                 +     D                        +
 12 +                 +   D                          +
 13 +               D +                              +
 14 +        D        +                              +
 15 +                 D                              +
 16 +                 +      D                       +
 17 +                 +        D                     +
 18 +                 +D                             +
 19 +                D+                              +
 20 +             D   +                              +
 21 +                D+                              +
 22 +              D  +                              +
 23 +                D+                              +
 24 +              D  +                              +
 25 +                 + D                            +
 26 +                 + D                            +
 27 +                 +  D                           +
 28 +               D +                              +
 29 +                D+                              +
 30 +              D  +                              +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                   -  0  +
```

Figure 6.10. Plot of response of RRate to a one-standard deviation shock in Deficit

```
Step
    +++++++++++++++++++++++++++++++++++++++++++++++++++
 1  +                                +            D   +
 2  +   D                            +                +
 3  D                                +                +
 4  +         D                      +                +
 5  +                  D             +                +
 6  +                      D         +                +
 7  +                                +         D      +
 8  +                                +        D       +
 9  +                                +                D
10  +                                +               D+
11  +                            D   +                +
12  +              D                 +                +
13  +                   D            +                +
14  +                    D           +                +
15  +                               D+                +
16  +                                +    D           +
17  +                                +       D        +
18  +                                +    D           +
19  +                                +    D           +
20  +                             D  +                +
21  +                         D      +                +
22  +                        D       +                +
23  +                              D +                +
24  +                                +D               +
25  +                                +       D        +
26  +                                +     D          +
27  +                                +    D           +
28  +                                D                +
29  +                             D  +                +
30  +                         D      +                +
    +++++++++++++++++++++++++++++++++++++++++++++++++++
                                  -  0  +
```

Figure 6.11. Plot of response of Returns to a one-standard deviation shock in Deficit

```
Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
  1  +                    D            +              +
  2  D                                 +              +
  3  +                              D  +              +
  4  +            D                    +              +
  5  +                           D     +              +
  6  +                         D       +              +
  7  +                                 +   D          +
  8  +                             D   +              +
  9  +                                 +              D
 10  +                              D  +              +
 11  +                                D+              +
 12  +                        D        +              +
 13  +                                 + D            +
 14  +                       D         +              +
 15  +                                 +   D          +
 16  +                           D     +              +
 17  +                                 +   D          +
 18  +                              D  +              +
 19  +                                 +    D         +
 20  +                          D      +              +
 21  +                                 + D            +
 22  +                           D     +              +
 23  +                                 +   D          +
 24  +                              D  +              +
 25  +                                 +      D       +
 26  +                              D  +              +
 27  +                                 +    D         +
 28  +                             D   +              +
 29  +                                 + D            +
 30  +                           D     +              +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
                                    -  0  +
```

Figure 6.12. Plot of response of Value to a one-standard deviation shock in Deficit

```
Step
   ++++++++++++++++++++++++++++++++++++++++++++++++++
 1 +       M                              +         +
 2 +            M                         +         +
 3 M                                      +         +
 4 +                  M                   +         +
 5 +           M                          +         +
 6 +                    M                 +         +
 7 +         M                            +         +
 8 +              M                       +         +
 9 +          M                           +         +
10 +                                M     +         +
11 +                                     M+         +
12 +                                      +         M
13 +                                     M+         +
14 +                                      +         M
15 +                                      + M       +
16 +                                      +       M +
17 +                                  M   +         +
18 +                                   M  +         +
19 +                          M           +         +
20 +                                      M         +
21 +                                 M    +         +
22 +                                      + M       +
23 +                                 M    +         +
24 +                                      + M       +
25 +                                  M   +         +
26 +                                      +   M     +
27 +                                    M +         +
28 +                                      +   M     +
29 +                                     M+         +
30 +                                      +     M   +
   ++++++++++++++++++++++++++++++++++++++++++++++++++
                                       -  0  +
```

Figure 6.13. Plot of response of RRate to a one-standard deviation shock in M1

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
  1 M                       +                        +
  2 +                       +         M              +
  3 +                       +             M          +
  4 +                       +        M               +
  5 +                       +                        M
  6 +                       +                 M      +
  7 +                       +        M               +
  8 +                       +            M           +
  9 +                       +  M                     +
 10 +                       M                        +
 11 +                     M +                        +
 12 +                       M                        +
 13 +                    M  +                        +
 14 +                       M                        +
 15 +                     M +                        +
 16 +                    M  +                        +
 17 +                   M   +                        +
 18 +                       M                        +
 19 +                     M +                        +
 20 +                       +  M                     +
 21 +                       +  M                     +
 22 +                       +   M                    +
 23 +                       +  M                     +
 24 +                       +  M                     +
 25 +                     M +                        +
 26 +                     M +                        +
 27 +                   M   +                        +
 28 +                     M +                        +
 29 +                     M +                        +
 30 +                       +M                       +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                          -  0  +
```

Figure 6.14. Plot of response of Returns to a one-standard deviation shock in M1

```
Step
     ++++++++++++++++++++++++++++++++++++++++++++++++++
   1 + M            +                                 +
   2 +              +                       M         +
   3 +     M        +                                 +
   4 +              +                       M         +
   5 +              +                     M           +
   6 +              +                             M   +
   7 +              +           M                     +
   8 +              +                                 M
   9 +             M+                                 +
  10 +              +                M                +
  11 +           M  +                                 +
  12 +              +      M                          +
  13 +  M           +                                 +
  14 +              +      M                          +
  15 M              +                                 +
  16 +              +  M                              +
  17 +    M         +                                 +
  18 +              +     M                           +
  19 +       M      +                                 +
  20 +              +           M                     +
  21 +           M  +                                 +
  22 +              +           M                     +
  23 +            M +                                 +
  24 +              +         M                       +
  25 +       M      +                                 +
  26 +              +      M                          +
  27 +     M        +                                 +
  28 +              +   M                             +
  29 +      M       +                                 +
  30 +              +    M                            +
     ++++++++++++++++++++++++++++++++++++++++++++++++++
                 -  0  +
```

Figure 6.15. Plot of response of Value to a one-standard deviation shock in M1

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
 1  +                         I   +                  +
 2  I                             +                  +
 3  +                  I          +                  +
 4  +       I                     +                  +
 5  +              I              +                  +
 6  +                        I    +                  +
 7  +                      I      +                  +
 8  +                             +              I   +
 9  +                             +             I    +
10  +                             +             I    +
11  +                             +                  I
12  +                             +      I           +
13  +                             +   I              +
14  +                             I                  +
15  +                      I      +                  +
16  +                    I        +                  +
17  +                       I     +                  +
18  +                        I    +                  +
19  +                         I   +                  +
20  +                            I+                  +
21  +                            I+                  +
22  +                            I+                  +
23  +                             + I                +
24  +                             +I                 +
25  +                             + I                +
26  +                             +  I               +
27  +                             +  I               +
28  +                             +I                 +
29  +                             +I                 +
30  +                           I  +                  +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                               -  0  +
```

Figure 6.16. Plot of response of Returns to a one-standard deviation shock in RRate

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
  1 +                   I         +                  +
  2 I                             +                  +
  3 +           I                 +                  +
  4 +          I                  +                  +
  5 +    I                        +                  +
  6 +               I             +                  +
  7 +                             +I                 +
  8 +                             +      I           +
  9 +                             +           I      +
 10 +                             +                 I+
 11 +                             +                  I
 12 +                             +         I        +
 13 +                             +            I     +
 14 +                             +  I               +
 15 +                         I   +                  +
 16 +                         I   +                  +
 17 +                        I    +                  +
 18 +                    I        +                  +
 19 +                         I   +                  +
 20 +                        I    +                  +
 21 +                          I  +                  +
 22 +                             I                  +
 23 +                             +  I               +
 24 +                             +I                 +
 25 +                             +    I             +
 26 +                             +   I              +
 27 +                             +   I              +
 28 +                             + I                +
 29 +                             + I                +
 30 +                           I +                  +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
                             -  0  +
```

Figure 6.17. Plot of response of Value to a one-standard deviation shock in RRate

```
Step
    ++++++++++++++++++++++++++++++++++++++++++++++++++
  1 +           +                                    R
  2 +           + R                                  +
  3 +           +               R                    +
  4 +           +          R                         +
  5 +    R      +                                    +
  6 + R         +                                    +
  7 +      R    +                                    +
  8 R           +                                    +
  9 +   R       +                                    +
 10 +   R       +                                    +
 11 +          R+                                    +
 12 +R          +                                    +
 13 +          R+                                    +
 14 +       R   +                                    +
 15 +           R                                    +
 16 +           +  R                                 +
 17 +           +        R                           +
 18 +           + R                                  +
 19 +           +      R                             +
 20 +           R                                    +
 21 +           R                                    +
 22 +     R     +                                    +
 23 +         R +                                    +
 24 +    R      +                                    +
 25 +          R+                                    +
 26 +         R +                                    +
 27 +           + R                                  +
 28 +          R+                                    +
 29 +           +  R                                 +
 30 +         R +                                    +
    ++++++++++++++++++++++++++++++++++++++++++++++++++
             -  0  +
```

Figure 6.18. Plot of response of Value to a one-standard deviation shock in Returns

strongly negative, and sustained through step seven for Returns (Figure 6.16) and step six for Value (Figure 6.17). Finally, the response of Value to a Returns shock (Figure 6.18) is strongly positive and sustained through step four, a result which, as in the case of the five-lag, full-period model, lends credibility to these simulations of the four-lag, post-war model.

Decomposition of forecast error variance

Tables 6.8 through 6.12 summarize the decomposition of variance of each of the five variables of the X vector of the four-year-lag version of system 5.1 estimated over the post-war period. Innovations in M1 explain approximately one fourth of the variability in Deficit beginning at step two (Table 6.8), and the response of Deficit to an M1 shock is negative through step 12 with the exception of step four (see Table D.2, Appendix D). These data provide evidence that a relaxed monetary policy tends to lower the real value of the fiscal deficit. Furthermore, the observation that the greatest share of the variability in M1 (62 percent at step 15; Table 6.9) is explained by its own innovations confirms the exogeneity of M1 and suggests that M1 could be placed ahead of Deficit in the causal ordering of the X vector.

The positions of Deficit and M1 relative to one another in the causal order is not of fundamental importance in this study, however, provided that the two variables appear as the first two elements of the X vector. As was the case in the full-period model, weak evidence of feedback from Returns to Deficit is also apparent in Table 6.8. Again,

Table 6.8. Decomposition of the forecast error variance of Deficit

	Variance in Deficit attributed to innovations in:				
Step	Deficit	M1	RRate	Returns	Value
	Percent				
1	100.000000	0.0	0.0	0.0	0.0
2	65.942899	24.294492	0.390913	7.319933	2.051763
3	56.813862	28.457777	2.547242	10.293476	1.887643
4	52.276363	25.562295	9.387424	10.749640	2.024278
5	48.879151	23.745911	10.048029	15.038020	2.288889
6	45.179212	21.754191	9.469118	21.207320	2.390159
7	44.219010	21.814742	9.218082	21.946260	2.801906
8	41.645487	24.271755	10.556835	20.813923	2.712000
9	38.966619	24.950584	9.878706	23.331089	2.873003
10	37.110976	23.807753	9.327551	26.650075	3.103645
11	36.783457	23.287615	9.867609	27.061468	2.999850
12	35.945449	23.121696	10.120639	27.715408	3.096808
13	36.276863	22.720191	10.337770	27.377317	3.287859
14	36.453402	22.429129	10.543376	27.336728	3.237365
15	35.915331	22.310713	10.417423	28.160984	3.195548

Table 6.9. Decomposition of the forecast error variance of M1

	Variance in M1 attributed to innovations in:				
Step	Deficit	M1	RRate	Returns	Value
	Percent				
1	3.642927	96.357073	0.0	0.0	0.0
2	2.811653	85.398447	0.470740	1.172769	10.146390
3	4.872686	79.877454	2.162651	1.098206	11.989003
4	4.594898	75.809507	6.621015	1.636874	11.337706
5	6.521325	74.055116	5.709396	2.003852	11.710311
6	8.104085	71.248006	6.193732	1.972929	12.481248
7	9.898564	69.969625	5.349097	4.031288	10.751426
8	10.314113	69.211562	5.419263	4.442906	10.612155
9	10.140086	66.695710	5.538723	5.812765	11.812716
10	10.177749	65.227948	5.570484	6.706272	12.317546
11	11.012157	64.735354	5.444619	6.724726	12.083145
12	10.913868	64.249684	5.773022	6.831466	12.231960
13	10.721893	64.079732	6.278595	6.725522	12.194259
14	10.723688	63.914019	6.278376	6.847902	12.236014
15	10.891383	62.440472	6.242666	7.927027	12.498453

this evidence is not sufficiently strong to warrant reconsideration of the placement of Deficit and M1 at the head of the causal ordering of the X vector.

From the data of Table 6.10, RRate is clearly not an exogenous variable in this model. Innovations in both Deficit and M1 explain significant portions of the variability in RRate. These decomposition of variance data for RRate indicate that the positive response of RRate to a Deficit shock observed in Figure 6.10 is fairly immediate, that the negative response of RRate to an M1 shock observed in Figure 6.13 occurs with a lag of about two years, and that innovations in Deficit and M1 explain nearly equal proportions of the variability in RRate at step three. Recall that the response of RRate to a Deficit shock (Figure 6.10) becomes erratic at step four but that the negative response of RRate to an M1 shock is sustained through step eleven (Figure 6.13). These observations taken together suggest that a Deficit shock has an immediate, positive effect on RRate and that an M1 shock has a negative effect on RRate which occurs with a lag but which is sustained for a considerably longer period than that of the Deficit shock.

The most cogent data in this investigation are found in Tables 6.11 and 6.12, the decomposition of variance for Returns and Value, respectively. Although the greatest proportion of the variability in Returns is explained by its own innovations, innovations in RRate also explain a significant percentage of the variation in Returns (Table 6.11). Noting that the response of Returns to a RRate shock was negative

Table 6.10. Decomposition of the forecast error variance of RRate

Step	Variance in RRate attributed to innovations in: Deficit	M1	RRate	Returns	Value
	--------------------	------	Percent	------	--------------------
1	14.911222	11.982828	73.105950	0.0	0.0
2	21.985654	11.862081	59.420613	0.010819	6.720833
3	20.879525	19.180088	51.062715	0.886915	7.990756
4	22.485093	19.834999	48.926075	1.026370	7.727464
5	22.406545	21.459590	47.455669	1.470805	7.207391
6	21.943966	21.800453	44.955404	3.468397	7.831780
7	24.668400	23.573298	41.325713	3.267503	7.165087
8	22.662167	23.836173	41.529017	5.304888	6.667756
9	20.354424	23.968897	40.430892	8.316273	6.929514
10	19.563326	23.046853	38.858061	11.612229	6.919531
11	19.447201	22.625467	38.529244	12.240443	7.157645
12	19.159563	22.451651	39.242603	12.109493	7.036690
13	18.998629	22.256104	39.517942	12.168819	7.058506
14	19.242205	22.279752	39.086730	12.413386	6.977927
15	19.148163	22.176097	39.043036	12.684619	6.948084

Table 6.11. Decomposition of the forecast error variance of Returns

	Variance in Returns attributed to innovations in:				
Step	Deficit	M1	RRate	Returns	Value
	-----Percent-----				
1	0.657665	13.368151	0.282943	85.691241	0.0
2	3.434382	11.162199	16.527280	62.639261	6.236877
3	6.295646	12.544273	15.791953	59.512915	5.855215
4	7.194606	12.561751	21.023196	53.791190	5.429257
5	6.545429	17.624733	20.275582	50.575953	4.978305
6	6.335918	19.979579	19.176724	49.244344	5.263434
7	6.134644	19.616983	18.490672	50.801923	4.955778
8	6.027512	20.339738	20.212585	48.646346	4.773820
9	6.321651	19.844889	21.746090	47.264677	4.822692
10	6.576649	19.350405	23.119786	46.086996	4.866164
11	6.349308	18.598155	25.675510	44.702620	4.674407
12	6.814643	18.351442	25.902294	44.239813	4.691809
13	7.069663	18.241096	25.865591	44.118583	4.705067
14	7.286712	18.123847	25.696164	44.207694	4.685582
15	7.239135	18.012243	25.941297	44.152848	4.654478

Table 6.12. Decomposition of the forecast error variance of Value

Step	Variance in Value attributed to innovations in:				
	Deficit	M1	RRate	Returns	Value
	Percent				
1	2.815688	4.468130	5.186431	70.329995	17.199757
2	12.778983	10.566312	28.107302	39.041662	9.505741
3	10.689663	9.784256	30.936557	38.341375	10.248148
4	11.745852	13.799335	32.172201	33.578921	8.703691
5	9.996315	15.609958	37.076895	28.699136	8.617696
6	9.161732	20.431033	35.652664	26.616316	8.138253
7	8.967894	20.908889	34.681857	26.153682	9.287679
8	8.092850	26.040763	31.565609	25.081688	9.219090
9	8.735490	25.170013	32.233846	24.859772	9.000879
10	8.210872	25.325136	33.643359	23.976391	8.844241
11	7.902082	24.420788	36.093546	23.072895	8.510688
12	7.851401	23.710612	35.695497	23.422855	9.319635
13	7.670888	23.796005	36.532632	22.844429	9.156046
14	7.955479	23.730973	36.159248	22.736589	9.417711
15	7.900150	24.517489	35.800923	22.426944	9.354493

at steps one through seven (Figure 6.16), these data support the hypothesis of a negative causal association running from RRate to Returns as specified in the second channel of macroeconomic policy discussed in Chapter Five. Recall that evidence in support of this hypothesis was absent in the analysis of the full-period VAR of the previous section.

The data of Table 6.11 also show that innovations in M1 explain a percentage of the variability in Returns which is only marginally significant at steps one through four but is equal to the percentage of the variability in Returns explained by RRate thereafter. The initial response of Returns to an M1 shock observed in Figure 6.14 is negative, but the response is positive at steps two through nine. These data suggest that an M1 shock has a slight, positive effect on Returns, an effect which occurs with a lag of three to four years. Finally, evidence supporting the significance of the negative response of Returns to a Deficit shock noted in steps two through six of Figure 6.11 is not present in the data of Table 6.11.

The percentage of the variability in Value explained by its own innovations in the post-war estimation (Table 6.12) is approximately one-half that explained by its own innovations in the full-period estimation (Table 6.5). That is, more of the variability in Value is explained by the other four variables in the model in the post-war period than in the full period. Moreover, innovations in Returns explains a substantially smaller proportion of the variability in Value in the post-war model than in the full-period model at all steps after the first.

Innovations in RRate, however, assume a much more prominent role in the explanation of variability in Value relative to the results of the full-period estimation. Indeed, the data of Table 6.12 show that innovations in RRate explain more than one-fourth of the variability in Value at step two, a proportion (one third) nearly equal to that explained by innovations in Returns at step four, and a proportion exceeding that explained by Returns thereafter. Noting that the response of Value to a RRate shock is negative at steps one through six in Figure 6.17, these data support the hypothesis of a significant, negative, causal relationship running from RRate to Value as specified in the first channel of macroeconomic policy developed throughout the previous chapters. Recall that support for this hypothesis was conspicuously absent in the simulations of the full-period model.

Little evidence is available in Table 6.12 to suggest that innovations in M1 have a significant causal association with Value. The proportion of variability in Value explained by innovations in M1 does not approach significance until step five. In addition, the response of Value to an M1 shock plotted in Figure 6.15 is erratic during the initial steps.

Finally, the percentage of the variability in Value explained by innovations in Deficit approaches significance at steps two through four and then declines throughout the simulation horizon. Although the response of Value to a Deficit shock is consistently negative and in agreement with the result predicted by the theoretical model at steps one through six, this evidence of a significant, negative, causal association running directly from Deficit to Value is weak.

Analysis of alternative orderings

The only evidence of significant correlation among the elements of the innovation vector U contained in Tables 6.8 through 6.12 is found in the decomposition of variance for RRate at step one (Table 6.10). Marginally significant percentages of the first-step variance of RRate are explained by innovations in Deficit and M1, a sign of correlation among the residuals of these three variables. Because innovations in RRate explain the greatest share of the variability in Returns and Value relative to the shares explained by innovations in Deficit and M1 even though RRate follows Deficit and M1 in the causal ordering, one would not expect significant changes in the results described above if RRate were ordered ahead of Deficit and M1.

Nonetheless, the simulations of system 5.1 described above were repeated after reversing the order of the first three elements of the X vector. The decomposition of variance data for the variables Returns and Value derived from the alternative ordering RRate, M1, Deficit, Returns, Value appear in Tables 6.13 and 6.14. As expected, the relative importance of innovations in RRate in explaining the variance in Returns and Value improved slightly at the expense of the explanatory power of Deficit and M1. The results from this alternative ordering of the X vector provide no evidence to suggest that the interpretation of the data from the original analysis is in error.

Table 6.13. Decomposition of the forecast error variance of Returns

Step	Variance in Returns attributed to innovations in: RRate	M1	Deficit	Returns	Value
			Percent		
1	1.263385	12.969710	0.075664	85.691241	0.0
2	21.961057	9.108274	0.054530	62.639261	6.236877
3	24.624469	9.098055	0.909347	59.512915	5.855215
4	31.747016	8.210651	0.821886	53.791190	5.429257
5	33.302184	10.307638	0.835921	50.575953	4.978305
6	32.703560	12.004221	0.784441	49.244344	5.263434
7	31.294577	11.606898	1.340824	50.801923	4.955778
8	31.100015	14.194993	1.284827	48.646346	4.773820
9	32.190127	14.441248	1.281256	47.264677	4.822692
10	33.406170	14.376543	1.264128	46.086996	4.866164
11	34.560706	14.112273	1.949994	44.702620	4.674407
12	34.222926	14.041636	2.803817	44.239813	4.691809
13	33.966378	13.910096	3.299876	44.118583	4.705067
14	33.764262	13.829561	3.512900	44.207694	4.685582
15	33.819769	13.857198	3.515707	44.152848	4.654478

Table 6.14. Decomposition of the forecast error variance of Value

Step	Variance in Value attributed to innovations in: RRate	M1	Deficit	Returns	Value
	---------------------------	----------	Percent	----------	---------------------------
1	3.472429	7.691812	1.306008	70.329995	17.199757
2	45.145022	4.862158	1.445418	39.041662	9.505741
3	41.958568	7.950964	1.500944	38.341375	10.248148
4	48.362931	8.060603	1.293855	33.578921	8.703691
5	53.329708	7.137531	2.215929	28.699136	8.617696
6	53.680364	9.327505	2.237561	26.616316	8.138253
7	52.224878	10.022958	2.310804	26.153682	9.287679
8	46.907200	16.724122	2.067900	25.081688	9.219090
9	47.607504	16.355275	2.176570	24.859772	9.000879
10	45.720090	19.106806	2.352472	23.976391	8.844241
11	46.928351	18.674146	2.813920	23.072895	8.510688
12	45.335845	18.690748	3.230918	23.422855	9.319635
13	46.317439	18.290854	3.391232	22.844429	9.156046
14	45.789830	18.379435	3.676435	22.736589	9.417711
15	45.179051	19.390139	3.649373	22.426944	9.354493

Summary of the Empirical Analyses

The results of the innovation accounting techniques applied to the VAR model of equations 5.1 through 5.3 estimated over the entire data period from 1935 (with lags extending to 1930) through 1985 are generally consistent with the hypotheses derived from the conceptual model of Chapter Four. The results lend support to the hypothesis of a negative, causal association between shocks in the money supply measured by M1 and the real rate of interest, RRate. More than one-third of the forecast error variance in RRate is attributed to innovations in M1 at all forecast horizons. The positive response of RRate to a Deficit shock predicted in the conceptual model is also verified in the empirical tests; however, innovations in Deficit explain a much smaller proportion of RRate variability than do innovations in M1. Together innovations in the two macroeconomic policy variables, Deficit and M1, explain more than one-half of the variability in RRate. These results suggest that macroeconomic policy has been an important determinant of the real rate of interest as defined by the variable RRate in this model, and that monetary policy has played a more important role than fiscal policy in determining the level of the real rate during this period of estimation.

The fiscal deficit rather than the money supply, however, was found to be a significant factor in determining both returns to land and land value. Consistent with the hypotheses developed in earlier chapters, a fiscal deficit shock was found to be negatively associated with the Returns and Value series. Especially notable in these data is the fact that at step six in the forecast horizon, the proportion of variability in Value explained by Deficit is nearly equal to that explained by Returns and considerably larger than that explained by innovations in Value itself.

Although the negative associations between Deficit and Returns and between Deficit and Value provide preliminary support for the validity of the portfolio-balance model developed in Chapter Four, the evidence that fiscal deficit shocks are transmitted to the agricultural sector through the real rate of interest as hypothesized in Chapter Five is incomplete. The relationship of the real rate of interest to fiscal deficit and money supply shocks found in these data is consistent with the predictions of the conceptual model. Likewise, the relationship of returns to land and land value to a fiscal deficit shock discovered in these data is also consistent with the predictions of the conceptual model. The data do not support, however, the hypothesis of a causal relationship existing between the real rate of interest and either returns to land or land value. Since the premise upon which the portfolio-balance model is built is that asset prices respond to shifts in relative rates of return, this result is sufficient cause for concern about the validity of the model of Chapter Four.

The anamoly of the missing link between macroeconomic policy, represented by the variables Deficit and M1, and the agricultural sector, represented by the variables Returns and Value, could be due in part to the crude definition of the real rate of interest used in this analysis. Limited experimentation with alternative definitions of RRate included adjustment of the nominal rate of interest by either the rate of inflation lagged one year or the three-year moving average of current and past inflation rates rather than by the contemporaneous rate of inflation. The results of these preliminary experiments did not differ substantially from those reported above.

Observation of the original RRate series did reveal, however, that the series is much more stable in the post World War II period than in the years prior to the early 1950s. To test the hypothesis that the real rate of interest might have greater explanatory power with regard to returns to land and land value in the post-war period, the general VAR model of equations 5.1 through 5.3 with the lag length shortened from five years to four years to ensure convergence of the model was estimated over the period 1946 (with lags extending to 1942) through 1985. Consistent with the results of the full-period estimation of the model, the macroeconomic policy variables Deficit and M1 explain a significant percentage of the variance in RRate, and the direction of the response of RRate to the policy variable shocks is in agreement with the theoretical model. In addition, the data suggest that in the short run, fiscal deficit shocks are more important than money shocks in determining the level of the real rate of interest in the post-war period but that the effect of a money shock is more important in the longer run.

Contrary to the results of the full-period estimation, money supply shocks rather than fiscal deficit shocks were found to have a direct and positive, causal relationship with returns to land. Although the effect of an M1 shock on Returns is only marginally significant, this finding lends support to the empirical results of Starleaf, Meyers, and Womack and, to an even greater degree, those of Falk, Devadoss, and Meyers. Of greater significance for this study, however, is the discovery in the post-war data of a pronounced, negative effect of a real rate shock on returns to land. One admittedly speculative hypothesis for the source of this effect, the circuitous, second channel of macroeconomic policy entailing the transmission of domestic macroeconomic policy shocks through shifts in the exchange value of the U.S. dollar, was set forth in Chapter Five, but a sound, theoretical basis for a negative effect of the real rate of interest on returns to land is not present in the conceptual model of Chapter Four. Clearly, this is an area in which the data suggest that additional research be undertaken.

Of greatest significance to the empirical test of the portfolio-balance model of land price determination is the response of land value itself to each of the other four variables in the model. Only an insignificant proportion of the variation in Value is explained by its own innovations in the post-war period. Moreover, the direction of the Value response to a shock in Deficit, RRate, or Returns is consistent with the predictions of the theoretical model, and the erratic Value response to an M1 shock is not significant in relation to the magnitude of the response of Value to the other three variables in the model.

By virtue of the orthogonalization of the innovation vector U (equation 5.1) before implementation of the innovation accounting procedures, the marginally significant, negative response of Value to a Deficit shock found in the post-war data can be construed to be a direct response of Value to the Deficit shock independent of the response of

Value to a RRate shock. An explanation of the direct response of Value to a Deficit shock is not found in the theoretical model of Chapter Four. The effect is not large, however, in comparison to the significant negative response of land value to a shock in the real rate of interest. Indeed, RRate explains as much of the variance in Value as does Returns in the post-war period. Together with the observed response of the real rate of interest to a macroeconomic policy shock, a positive response with respect to a Deficit shock and a negative response with respect to an M1 shock, these results suggest strongly that macroeconomic policy decisions affect land value through a shift in the real rate of interest precisely as predicted in the conceptual, portfolio-balance model of land valuation developed in this study.

CHAPTER SEVEN: CONCLUSIONS

Summary of Major Findings

Three distinct methods of inquiry are employed in this investigation of the existence and extent of relationships between macroeconomic policy and events in the farmland market in the United States. First, somewhat casual observation of trends in plotted data is used to discern an association between macroeconomic policy decisions and the price of farmland, an association which is most evident during the remarkable cycle in the average price of farmland during the 1970s and 1980s. More specifically, the data suggest that an increase in the fiscal deficit and a decrease in the rate of growth of the money supply are accompanied by an increase in the ex post real rate of interest and a decrease in the price of farmland.

Second, following a review of the standard model of land value derived from the capitalization of a stream of net returns, a conceptual model relating changes in the real price of land to shifts in macroeconomic policy is developed. Experiments performed with the conceptual model indicate that the associations observed in the data are consistent with macroeconomic theory and particularly with that part of macroeconomic theory captured in the concepts of the portfolio-balance model. Study of the conceptual model led to a formal statement of the hypotheses upon which this study is based. In summary, these hypotheses assert that an expansionary fiscal policy conducted in an environment of monetary restraint leads to 1) an increase in the real rate of interest, 2) a decline in returns to land, and 3) a decline in land value.

Finally, more formal and more objective methods of observation are applied to the data observed in the first stage of the study. The results of these methods, the econometric techniques of vector autoregression, are in agreement with the observations noted in the more casual analysis of the data as well as with the hypotheses developed from the theoretical model. As is the case with the results of the visual inspection of the data, the results of the more formal analysis are more convincing when the analysis is confined to a study of the post World War II period.

In summary, all three methods of investigation used in the study lead to the same set of conclusions:

1) Macroeconomic policy plays a significant role in determining the level of the ex post real rate of interest. Positive money supply shocks tend to lower the real rate of interest and fiscal deficit shocks tend to increase the real rate of interest. In addition, the results from the empirical component of the study suggest that the effect of a deficit shock on the real rate is more immediate than that of a money supply shock.

2) An increase in the real rate of interest tends to lower returns to land. In addition, a lesser, direct, positive effect of a money supply shock on returns to land is apparent in the empirical analysis of the data from the post-war period.

3) An increase in the real rate of interest causes the real value of farmland to decline. Indeed, the empirical results indicate that the role of the real rate in determining the value of farmland has been as significant as that of returns to land during the post-war period. In addition, a lesser, direct, negative effect of a deficit shock on land value is noted in the empirical analysis of the post-war data.

Significance of this Research

This research adds to the growing body of literature describing the efforts of agricultural economists to gain an understanding of the interrelationships between the agricultural sector and the general economy. The focus of much of the research in this area has been on the response of farm-level prices or incomes to events in the macroeconomy. The study reported herein carries this current research interest an additional step from incomes to asset values.

Most previous land value research has placed major emphasis on the stream of net returns accruing to land as the primary determinant of land value. Although the net returns stream is not neglected, the emphasis of this investigation is clearly on the discount rate applied to the net returns stream rather than the net returns stream itself. Indeed, the discount rate, and more specifically, the real rate of interest, is treated as the primary link between macroeconomic policy and the value of farmland.

The conceptual definition of the linkage of macroeconomic policy to land value through the real rate of interest is established in a dynamic, portfolio-balance model. Although the general concept of the portfolio-balance model used in this study was introduced over fifteen years ago, the application of the concept to the problem of land value determination is a much more recent development. Indeed, the development of the portfolio-balance model as a tool to study the general issue of the effects of macroeconomic policy on farmland value apart from side issues of taxation is one of the primary objectives of this study.

Although this dissertation is not by design a study of agricultural policy, the findings of the study do, nonetheless, have significant policy implications. The results of the study show a clear, causal relationship between macroeconomic policy and extraordinary swings in land value during the post-war period. Given the predominant position of farm real estate on the aggregate balance sheet of the farm sector, large changes in the value of farm real estate have a significant effect on the financial well-being of the farming sector.

To the extent that one of the goals of macroeconomic policy is the maintenance of stability in all sectors of the economy, a case for some form of sector-specific, policy intervention to counter the adverse effects of macroeconomic policy in certain sectors of the economy--notably the agricultural sector of the 1980s--can be constructed. The objective of the sector-specific intervention would be the avoidance of costly dislocations of resources caused by ephemeral shifts in macroeconomic policy. Alternatively, in the case of an abrupt shift to a new set of macroeconomic policies which are judged to be sustainable and reasonably long-lived, the sector-specific policy objective would be to facilitate an orderly adjustment within the affected sectors to the new macroeconomic regime.

Limitations of this Research

Important limitations encountered in the completion of this research arise from three sources, the theoretical model, the data, and the empirical methods.

Limitations of the theoretical model

The conceptual model described in Chapter Four is necessarily a model of a very simple, idealized economy; the addition of complexities which would make the model more realistic would also lead the model toward mathematical intractability. Nonetheless, one must immediately recognize two important issues, among others, which are omitted from explicit consideration in the model.

The first, glaring omission from the theoretical model is the explicit consideration of the effects of risk. The approach followed in this study is similar to that taken by Foley and Sidrauski in which the effects of risk are acknowledged implicitly but not explicitly. In a world of risky rates of return on assets, typical risk-averse investors will diversify wealth portfolios among assets of different expected rates of return as specified in the asset demands of the conceptual model of this study. A more explicit statement of the effects of risk in the asset demands of this model would require the incorporation of assumptions about risk perceptions and preferences of investors and of correlations among returns on assets that would cloud the analysis of the central issues of concern to the study.

The second omission is the consideration of the economy of the rest of the world. As noted elsewhere in the study, this domestic economy model lends itself to speculation on the transmission of domestic macroeconomic policy shocks to the agricultural sector through the exchange value of the dollar, but the model does not provide a sound, theoretical basis for formulating a testable hypothesis concerning this open-economy effect.

Limitations of the data

The most notable limitation among the data series employed in the empirical research is the crude definition used for the real rate of interest (RRate). Brief experimentation with slightly more sophisticated definitions than that of the simple adjustment of a long-term rate by the contemporaneous rate of inflation did not appear to alter the empirical results substantially. Nonetheless, the use of a real rate definition which incorporates expectations of the rate of inflation more carefully than the simple ex post real rate used in this analysis would at least improve the appearance of the research.

Of the data series required for the empirical analysis in this study, the only series which were limiting in themselves were the series of gross cash rents (Returns) and land values (Value). Ideally, lengthy series of valid net cash rent and land value data aggregated across the entire United States would be used in the study. These data are not available, but alternatives which seem reasonable are developed. First, a series of gross cash rents is substituted for net cash rents, a substitution which is not believed to have a substantive effect on the results of the study. Second, rather crude series of weighted-average, gross cash rents and land values are calculated from the data available for a sample of only 11 states. An improved weighting scheme implemented with a larger sample of data would probably yield series of data more reflective of land returns and value in the U.S. as a whole. Nonetheless, plots of the data series used in the empirical analysis provide no evidence that the data chosen for use in the study were exceptional.

Limitations of the empirical methods

The techniques of vector autoregression employed in the empirical analysis were recently developed but are proving to be useful methods of discovering relationships which exist among data of interest to economists. However, the interpretation of the results from these techniques are not always straight forward. Perhaps more alarming to the reader of this paper is the almost total absence of tests of statistical significance of the presented results. The arbitrarily chosen critical value established at 10 to 15 percent of the total variance explained and used in the interpretation of the decomposition of variance tables is not a reassuring substitute for the t and F statistics.

In spite of these shortcomings, the VAR model does appear to complete satisfactorily the task which it was assigned to do. That is, the unstructured, VAR model does uncover regularities existing among the data of concern to the study. Furthermore, the results of the VAR analyses are especially convincing when viewed in tandem with the conceptual model they were designed to test.

Implications for Further Research

The most obvious suggestions for improving the conceptual model developed in this research are derived from the two limitations on the applicability of the model as cited above. The incorporation of a more explicit treatment of risk in the theoretical model is likely to be a formidable task. Feldstein's efforts to include risk explicitly in a smaller portfolio-balance model are indicative of the adventures in mathematics and the types of data which are required for the task. Researchers with a primary interest in issues of risk analysis rather than in the effects of macroeconomic policy decisions on the agricultural sector are likely to be most satisfied with the results of such an effort and are encouraged to tackle this analytically difficult problem.

The inclusion of the economy of the rest of the world in the theoretical model would represent a substantial improvement in this analysis. As indicated in Chapter One, the data indicate that the rise and fall of the quantity of agricultural products exported from the United States has played a significant role in the economy of the U.S. agricultural sector during the 1970s and 1980s. The explicit inclusion of the economy of the rest of the world in the conceptual model would eliminate the need to speculate on the response of the domestic agricultural sector to shocks transmitted through or originating in foreign economies.

The principle empirical findings reviewed above are substantive in their own right but are best viewed--as is the case with most research--as preliminary to more thorough and far-reaching analyses. Several specific topics for future investigation are readily apparent in the empirical results of the study. First of all, more precise statements on the magnitudes of the effects of deficit and money supply shocks on the real rate of interest and, in turn, on land returns and land value than those reported in this study would be an interesting contribution to knowledge in general and a valuable resource in applied policy analysis. Estimates of the magnitudes of these effects are most readily obtained from more traditional, structural models than from the VAR model presented in this research.

In this sense the VAR model is a powerful tool for discovering underlying regularities in the data prior to and as an aid in the development of a more traditional structural model. The results reported above should be sufficient to encourage one to proceed with the building of a structural model patterned after the conceptual portfolio-balance model developed in this study. Alternatively, a portfolio-balance model of asset valuation could be included as a component in existing structural models. In either case, future research should focus on the specific linkages between domestic macroeconomic policy, the real rate of interest (however defined), and returns to land as well as land value in empirical models which include explicit consideration of the existence of foreign economies.

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APPENDIX A:

COMPARATIVE STATICS OF THE ASSETS MARKETS IN THE FOUR-ASSET CONCEPTUAL MODEL

In this appendix, the derivation of the three reduced-form equations describing the assets markets of the four-asset conceptual model of Chapter Four is provided. For convenience, the structural equations describing the assets markets of the conceptual model, equations 4.11 through 4.23, are restated below as equations A.1 through A.13. Recall that by Walras law, the four, asset-market equilibrium conditions are capable of determining a total of only three values, either rates of return on assets or asset prices. That is, the four equations A.3 through A.6 are not independent and must always add to the value of total wealth determined in constraint A.1. The three values determined in the assets markets, the real price of capital, the real price of land, and the nominal rate of interest paid on government bonds, are specified in the reduced forms A.11, A.12, and A.13, respectively.

(A.1) $$W = (M + B)\, P_m + KP_k + L_0 P_L$$

(A.2) $$w = gP_m + kP_k + \ell P_L$$

where:

$$P_m = \frac{1}{P_c}$$

$$M+B = G$$

$$g = G/N$$

$$\ell = L_0/N$$

$$\text{(A.3)} \quad \frac{gP_m}{x} = L(w, y, \rho_m, \rho_b, \rho_k, \rho_L)$$

where: $x = g/m$

$$\text{(A.4)} \quad \left(1 - \frac{1}{x}\right) gP_m = H(w, y, \rho_m, \rho_b, \rho_k, \rho_L)$$

$$\text{(A.5)} \quad kP_k = J(w, \rho_m, \rho_b, \rho_k, \rho_L)$$

$$\text{(A.6)} \quad \ell P_L = R(w, \rho_m, \rho_b, \rho_k, \rho_L)$$

$$\text{(A.7)} \quad \rho_m = \frac{\dot{P}_m}{P_m} = \pi_m$$

$$\text{(A.8)} \quad \rho_b = i + \pi_m$$

$$\text{(A.9)} \quad \rho_k = \frac{R_k}{P_k} + \frac{\dot{P}_k}{P_k} = r_k + \pi_k$$

$$\text{(A.10)} \quad \rho_L = \frac{R_L}{P_L} + \frac{\dot{P}_L}{P_L} = r_L + \pi_L$$

$$\text{(A.11)} \quad P_k = P_k(g, k, \ell, x, \pi_m, \pi_k, \pi_L)$$

$$\text{(A.12)} \quad P_L = P_L(g, k, \ell, x, \pi_m, \pi_k, \pi_L)$$

$$\text{(A.13)} \quad i = i(g, k, \ell, x, \pi_m, \pi_k, \pi_L)$$

The addition of the fourth asset, land, to the three assets, money, capital, and bonds, included in the Foley and Sidrauski model adds complexity to the comparative statics of the assets markets. Only two reduced-form equations analogous to those of A.11 through A.13 are present in the three-asset model, and the expected sign of the partial derivative of each endogenous variable of the reduced-form equations with respect to each exogenous variable can be derived without ambiguity. However, a degree of ambiguity does accompany the sign of each of the partial derivatives considered in the three reduced-form equations of the four-asset model. The determination of the signs of the partial derivatives of equations A.11 through A.13 is the primary topic of the presentation which follows.

As a preliminary step to the analysis of the comparative statics of the assets markets, the marginal physical products of both capital and land must be expressed in greater detail to facilitate differentiation. The marginal physical product of capital in terms of the consumable, R_k, is stated in A.14. Equation A.15 represents the percentage marginal physical productivity of capital.

$$(\text{A.14}) \quad R_k = \frac{\partial F_c}{\partial k_c} = \frac{\partial F_I}{\partial k_I} \cdot P_k = \frac{\partial q_c}{\partial k_c} = \frac{\partial q_I}{\partial k_I} \cdot P_k$$

$$(\text{A.15}) \quad r_K = \frac{\partial q_c}{\partial k_c} \cdot \frac{1}{P_k} = \frac{\partial q_I}{\partial k_I}$$

The analogous expressions for land are somewhat more complex. Equation A.16 defines the marginal physical productivity of the fixed stock of land in terms of the consumable. The marginal physical productivity of the effective land input is determined in A.17, and, recalling the definitions of equations A.18 and A.19, is simplified in A.20.

$$(A.16)\quad R_L = \frac{\partial F_c}{\partial L_0} = \frac{\partial F_c}{\partial L} \cdot \frac{\partial L}{\partial L_0} = \frac{\partial F_c}{\partial L} \cdot e^{nt}$$

$$(A.17)\quad \frac{\partial F_c}{\partial L} = \frac{\partial N \cdot q_c}{\partial L} = \left[\frac{N \partial q_c}{\partial k_c} \frac{\partial k_c}{\partial N} + q_c\right] \frac{\partial N}{\partial L}$$

$$(A.18)\quad \frac{\partial k_c}{\partial N} = \frac{-k_c}{N}$$

$$(A.19)\quad \frac{N_0}{L_0} = \frac{N}{L} = B = \frac{dN}{dL}$$

$$(A.20)\quad \frac{\partial F_c}{\partial L} = \left[q_c - k_c \frac{\partial q_c}{\partial k_c}\right] B$$

The final expression for R_L is provided in A.23 following substitution of the definition of the per capita land supply, ℓ (A.22). Equation A.24 states the percentage marginal physical productivity of land and is analogous to equation A.15 derived for the capital input.

$$(A.21)\quad \frac{\partial F_c}{\partial L_0} = \left[q_c - k_c \frac{\partial q_c}{\partial k_c}\right] \frac{N_0\ e^{nt}}{L_0}$$

$$(A.22) \quad \ell = \frac{L_0}{N} = \frac{L_0}{N_0 e^{nt}}$$

$$(A.23) \quad R_L = \left[q_c - k_c \frac{\partial q_c}{\partial k_c}\right] \cdot \frac{1}{\ell}$$

$$(A.24) \quad r_L = \left[q_c - k_c \frac{\partial q_c}{\partial k_c}\right] \frac{1}{P_k \cdot \ell}$$

The next step in the derivation of the comparative statics of the assets markets of this model is the writing of the total differentials of the equilibrium conditions A.13 through A.16. By Walras law, however, the total differentials of only three of the equilibrium conditions must be determined. The total differentials of the equilibrium conditions for the money market (A.13), the capital market (A.15), and the land market (A.16) are specified in matrix form in equation A.25. Note that the definitions of the marginal physical productivities of land and capital derived earlier were required in writing these three total differentials.

$$(A.25) \quad \underset{\underline{A}}{\begin{bmatrix} (L_1 k + L_2 y_{P_k} + L_5 \gamma_1 + L_6 \delta_1) & (L_1 \ell + L_6 \delta_3) & L_4 \\ (J_1 k - k + J_5 \gamma_1 + J_6 \delta_1) & (J_1 \ell + J_6 \delta_3) & J_4 \\ (R_1 k + R_5 \gamma_1 + R_6 \delta_1) & (R_1 \ell - \ell + R_6 \delta_3) & R_4 \end{bmatrix}} \quad \underset{\underline{B}}{\begin{bmatrix} dP_k \\ dP_L \\ di \end{bmatrix}}$$

<u>C</u>

$$
= \begin{bmatrix}
\left(\frac{P_m}{x} - L_1 P_m\right) dg - \frac{gP_m}{x^2} dx - \left(L_1 P_k + L_2 y_k\right) dk - \left(L_1 P_L + L_6 \delta_4\right) d\ell \\
- J_1 P_m dg + \left(P_k - J_1 P_k\right) dk - \left(J_1 P_L + J_6 \delta_4\right) d\ell \\
- R_1 P_m dg - R_1 P_k dk + \left(P_L - R_1 P_L - R_6 \delta_4\right) d\ell
\end{bmatrix}
$$

$$
\begin{bmatrix}
- \left(L_3 + L_4\right) d\pi_m - L_5 \gamma_3 d\pi_k - L_6 \delta_5 d\pi_L \\
- \left(J_3 + J_4\right) d\pi_m - J_5 \gamma_3 d\pi_k - J_6 \delta_5 d\pi_L \\
- \left(R_3 + R_4\right) d\pi_m - R_5 \gamma_3 d\pi_k - R_6 \delta_5 d\pi_L
\end{bmatrix}
$$

where

$$L_1 = \frac{\overset{+}{\partial} L}{\partial w},\ L_2 = \frac{\overset{+}{\partial} L}{\partial y},\ L_3 = \frac{\overset{+}{\partial} L}{\partial \rho m},\ L_4 = \frac{\overset{-}{\partial} L}{\partial \rho_b},\ L_5 = \frac{\overset{-}{\partial} L}{\partial \rho_K},\ L_6 = \frac{\overset{-}{\partial} L}{\partial \rho_L},$$

$$J_1 = \frac{\overset{+}{\partial} J}{\partial w}, \qquad J_3 = \frac{\overset{-}{\partial} J}{\partial \rho m},\ J_4 = \frac{\overset{-}{\partial} J}{\partial \rho_b},\ J_5 = \frac{\overset{+}{\partial} J}{\partial \rho_k},\ J_6 = \frac{\overset{-}{\partial} H}{\partial \rho_L},$$

$$R_1 = \frac{\overset{+}{\partial} R}{\partial w}, \qquad R_3 = \frac{\overset{-}{\partial} R}{\partial \rho m},\ R_4 = \frac{\overset{-}{\partial} R}{\partial \rho_b},\ R_5 = \frac{\overset{-}{\partial} R}{\partial \rho_k},\ R_6 = \frac{\overset{+}{\partial} R}{\partial \rho_L},$$

$$\gamma_1 = \frac{\overset{-}{\partial} \rho_k}{\partial P_k},\ \gamma_3 = \frac{\overset{+}{\partial} \rho_k}{\partial \pi_k}$$

$$\delta_1 = \frac{\overset{+}{\partial} \rho_L}{\partial P_k},\ \delta_3 = \frac{\overset{-}{\partial} \rho_L}{\partial P_L},\ \delta_4 = \frac{\overset{-}{\partial} \rho_L}{\partial \ell},\ \delta_5 = \frac{\overset{+}{\partial} \rho_L}{\partial \pi_L}$$

Expression A.26 is a coded version of A.25 in which each element of the matrices of A.26 represents the element in the same position in the corresponding matrix of A.25. The expected signs of the partial derivatives of A.25 and the elements of matrix $\underline{A}$ in A.26 are written above each derivative or matrix element, a convention which is used throughout this appendix.

$$\text{(A.26)}\quad \begin{array}{c} \underline{A} \\ \begin{bmatrix} \overset{+}{a}_{11} & \overset{+}{a}_{12} & \overset{+}{a}_{13} \\ \overset{-}{a}_{21} & \overset{+}{a}_{22} & \overset{-}{a}_{23} \\ \overset{+}{a}_{31} & \overset{-}{a}_{32} & \overset{-}{a}_{33} \end{bmatrix} \end{array} \begin{array}{c} \underline{B} \\ \begin{bmatrix} dP_k \\ dP_L \\ di \end{bmatrix} \end{array} = \begin{array}{c} \underline{C} \\ \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} \end{array}$$

The task which remains is to solve for the vector of unknowns, vector $\underline{B}$, by premultiplying both sides of A.26 by the inverse of matrix $\underline{A}$ as shown in equation A.27. The inverse of $\underline{A}$ is found by premultiplying the adjoint of $\underline{A}$ by the determinant of $\underline{A}$ (equation A.28). The adjoint of $\underline{A}$ is the transpose of matrix $\underline{D}$, the matrix of cofactors of the elements of $\underline{A}$. As shown in equation A.29, the signs of all but three of the elements of $\underline{D}$ are determined without ambiguity, and the ambiguous sign of element d_{13} leaves ambiguity in the sign of the determinant of $\underline{A}$ (equation A.30).

$$\text{(A.27)}\quad \underline{B} = \underline{A}^{-1}\,\underline{C}$$

$$\text{(A.28)}\quad \underline{A}^{-1} = \frac{1}{|\underline{A}|}\,D'$$

(A.29)

$$\underline{D} = \begin{bmatrix} a_{22}a_{33} - a_{23}a_{32} & -(a_{21}a_{33} - a_{23}a_{31}) & a_{21}a_{32} - a_{22}a_{31} \\ -(a_{12}a_{33} - a_{13}a_{32}) & a_{11}a_{33} - a_{13}a_{31} & -(a_{11}a_{32} - a_{12}a_{31}) \\ a_{12}a_{23} - a_{13}a_{22} & -(a_{11}a_{23} - a_{13}a_{21}) & a_{11}a_{22} - a_{12}a_{21} \end{bmatrix}$$

$$= \begin{bmatrix} \overset{-}{d}_{11} & \overset{-}{d}_{12} & \overset{?}{d}_{13} \\ \overset{+}{d}_{21} & \overset{?}{d}_{22} & \overset{+}{d}_{23} \\ \overset{?}{d}_{31} & \overset{+}{d}_{32} & \overset{+}{d}_{33} \end{bmatrix}$$

(A.30) $|\underline{A}| = \overset{+}{a}_{11}\overset{-}{d}_{11} + \overset{+}{a}_{12}\overset{-}{d}_{12} + \overset{-}{a}_{13}\overset{?}{d}_{13}$

The sign of element d_{13} and the determinant of $\underline{A}$ can be resolved through the application of additional tuition regarding the working of the portfolio balance model. Note that element d_{13} represents the difference between the product of own-price effects and cross-price effects on the excess demand functions for capital and land (equation A.31). If the product of the own-price effects (both negative) is greater than the product of the cross-price effects (both positive), then d_{13} is positive and the determinant of $\underline{A}$ is unambiguously negative.

(A.31) $d_{13} = a_{21}a_{32} - a_{22}a_{31} = \dfrac{\partial \overset{-}{X}J}{\partial P_k}\dfrac{\partial \overset{-}{X}R}{\partial P_L} - \dfrac{\partial \overset{+}{X}J}{\partial P_L}\dfrac{\partial \overset{+}{X}R}{\partial P_k} > 0$

An increase in the price of one asset, say capital, which is equivalent to a decrease in the rate of return on capital, results in a shift of wealth from capital (the own-price effect) to other alternative stores of wealth, money, bonds, and land (the cross-price effect). Since this induced increase in demand for alternative assets is distributed across three assets in this model, the assumption that the own-price effect exceeds the cross-price effect in magnitude is justified. Therefore, element d_{13} is assumed to carry a positive sign, and the determinant of $\underline{A}$ is assumed to carry a negative sign.

Similar logic regarding the relative magnitudes of own-price and cross-price effects in the assets markets can be used to resolve the amiguity in the signs of elements d_{31} and d_{22} (equations A.32 and A.33).

$$\text{(A.32)} \quad d_{31} = a_{12}a_{23} - a_{13}a_{22} = \frac{\partial \overset{+}{\bar{X}}L}{\partial P_L}\frac{\partial \bar{X}J}{\partial i} - \frac{\partial \bar{X}L}{\partial i}\frac{\partial \overset{+}{\bar{X}}J}{\partial P_L} > 0$$

$$\text{(A.33)} \quad d_{22} = a_{11}a_{33} - a_{13}a_{31} = \frac{\partial \overset{+}{\bar{X}}L}{\partial P_k}\frac{\partial \bar{X}R}{\partial i} - \frac{\partial \bar{X}L}{\partial i}\frac{\partial \overset{+}{\bar{X}}R}{\partial P_k} > 0$$

The first term in element d_{31} represents the product of cross-price effects between the financial asset markets (the money market and the interest rate) and the real asset markets (the capital market and the price of land). The second term is the product of the corresponding own-price effects within the market class, either financial or real. Applying logic identical to that used in resolving the sign of element d_{13}, the own-price effects are assumed to be greater in magnitude than the cross-price effects. Therefore, element d_{31} is assumed to be of positive sign. Finally, element d_{22} is also assumed to be of positive sign by maintaining the assumption that own-price effects with regard to market class are greater in magnitude than corresponding cross-price effects (equation A.33). Having resolved the ambiguity in the signs of the elements of $\underline{D}$ and the determinant of $\underline{A}$, the comparative statics of system A.34 can now be investigated.

$$\text{(A.34)} \quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \overset{\underline{D'}}{\begin{bmatrix} \bar{d}_{11} & \overset{+}{d}_{21} & \overset{+}{d}_{31} \\ \bar{d}_{12} & \overset{+}{d}_{22} & \overset{+}{d}_{32} \\ \overset{+}{d}_{13} & \overset{+}{d}_{23} & \overset{+}{d}_{33} \end{bmatrix}} \overset{\underline{C}}{\begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}}$$

Consider first of all the effects on the assets markets of a shock to the per capita government debt, g, holding all else constant. The $\underline{C}$ matrix in this case simplifies to the expression shown in A.35.

$$\text{(A.35)} \quad \underline{C} = \begin{bmatrix} \frac{P_m}{x} - L_1P_m \\ - J_1P_m \\ - R_1P_m \end{bmatrix} dg = \begin{bmatrix} \overset{?}{c}_1 \\ \bar{c}_2 \\ \bar{c}_3 \end{bmatrix} dg$$

The ambiguity in sign of the first element of the simplified $\underline{C}$ matrix,

c_1, is resolved by following the assumption of Foley and Sidrauski that the wealth elasticity of demand for money, $\frac{\partial L}{\partial w} \cdot \frac{w}{m}$, is much smaller than the ratio of w to g in equation A.36. Therefore, element c_1 is assumed positive.

$$\text{(A.36)} \quad C_1 = \frac{\partial L^S}{\partial g} - \frac{\partial L^D}{\partial g} = \left[1 - \frac{\partial L}{\partial w} \cdot \frac{w}{m} \cdot \frac{g}{w}\right] \frac{mP_m}{g} > 0$$

The results from this initial experiment in comparative statics are provided in system A.37, and as shown in A.38, a shock to the per capita debt increases the real prices of capital and land and has an indeterminant effect on the interest rate.

$$\text{(A.37)} \quad \underline{B} = \frac{\overset{-}{1}}{|\underline{A}|} \begin{bmatrix} \overset{-}{d}_{11}\overset{+}{c}_1 + \overset{+}{d}_{21}\overset{-}{c}_2 + \overset{+}{d}_{31}\overset{-}{c}_3 \\ \overset{-}{d}_{12}\overset{+}{c}_1 + \overset{+}{d}_{22}\overset{-}{c}_2 + \overset{+}{d}_{32}\overset{-}{c}_3 \\ \overset{+}{d}_{13}\overset{+}{c}_1 + \overset{+}{d}_{23}\overset{-}{c}_2 + \overset{+}{d}_{33}\overset{-}{c}_3 \end{bmatrix} dg$$

$$\text{(A.38)} \quad \frac{dP_k}{dg} > 0, \ \frac{dP_L}{dg} > 0, \ \frac{di}{dg} \gtrless 0$$

Next consider an increase in the monetary control variable x, all else constant. The $\underline{C}$ matrix in this case is shown in A.39, and the effects of the shock to x are summarized in A.40 and A.41. A shock to the monetary control variable x decreases the real prices of capital and land while increasing the interest rate.

$$\text{(A.39)} \quad \underline{C} = \begin{bmatrix} \frac{-gP_m}{x^2} \\ 0 \\ 0 \end{bmatrix} dx = \begin{bmatrix} \bar{c}_1 \\ c_2 \\ c_3 \end{bmatrix} dx$$

$$\text{(A.40)} \quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \begin{bmatrix} \bar{d}_{11}\ \bar{c}_1 \\ \bar{d}_{12}\ \bar{c}_1 \\ \overset{+}{d}_{13}\ \bar{c}_1 \end{bmatrix} dx$$

$$\text{(A.41)} \quad \frac{dP_k}{dx} < 0, \ \frac{dP_L}{dx} < 0, \ \frac{di}{dx} > 0$$

Equations A.42 through A.44 show the results of a shock in the per capita capital stock, all else constant. Although the signs of the terms of the simplified $\underline{C}$ matrix resulting from this shock are determinant (equation A.42), the direction of the effect of the shock to k on the real price of capital, the real price of land, and the interest rate are indeterminate (equation A.44).

$$\text{(A.42)} \quad \underline{C} = \begin{bmatrix} -(L_1P_k + L_2y_k) \\ P_k(1-J_1) \\ -R_1P_k \end{bmatrix} dk = \begin{bmatrix} \bar{c}_1 \\ \overset{+}{c}_2 \\ \bar{c}_3 \end{bmatrix} dk$$

$$\text{(A.43)} \quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \begin{bmatrix} \bar{d}_{11}\bar{c}_1 + \overset{+}{d}_{21}\overset{+}{c}_2 + \overset{+}{d}_{31}\bar{c}_3 \\ \bar{d}_{12}\bar{c}_1 + \overset{+}{d}_{22}\overset{+}{c}_2 + \overset{+}{d}_{32}\bar{c}_3 \\ \overset{+}{d}_{13}\bar{c}_1 + \overset{+}{d}_{23}\overset{+}{c}_2 + \overset{+}{d}_{33}\bar{c}_3 \end{bmatrix} dk$$

$$\text{(A.44)} \quad \frac{dP_k}{dk} \gtrless 0, \ \frac{dP_L}{dk} \gtrless 0, \ \frac{di}{dk} \gtrless 0$$

Similarly, the direction of the effect of a shock to the per capita land supply on the price of capital, the price of land, and the interest rate are indeterminate as shown in equations A.45 through A.47.

$$\text{(A.45)} \quad \underline{C} = \begin{bmatrix} -(L_1P_L + L_6\delta_4) \\ -(J_1P_L + J_6\delta_4) \\ P_L(1-R_1) - R_6\delta_4 \end{bmatrix} d\ell \ = \begin{bmatrix} \bar{c}_1 \\ \bar{c}_2 \\ \overset{+}{c}_3 \end{bmatrix} d\ell$$

$$\text{(A.46)} \quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \begin{bmatrix} \bar{d}_{11}\bar{c}_1 + \overset{+}{d}_{21}\bar{c}_2 + \overset{+}{d}_{31}\overset{+}{c}_3 \\ \bar{d}_{12}\bar{c}_1 + \overset{+}{d}_{22}\bar{c}_2 + \overset{+}{d}_{32}\overset{+}{c}_3 \\ \overset{+}{d}_{13}\bar{c}_1 + \overset{+}{d}_{23}\bar{c}_2 + \overset{+}{d}_{33}\overset{+}{c}_3 \end{bmatrix} d\ell$$

$$\text{(A.47)} \quad \frac{dP_k}{d\ell} \gtrless 0, \ \frac{dP_L}{d\ell} \gtrless 0, \ \frac{di}{d\ell} \gtrless 0$$

A shock to the rate of deflation, all else constant, is considered in equations A.48 through A.50. Element c_1 of the simplified $\underline{C}$ matrix in A.48 is of ambiguous sign. Assume, however, as Foley and Sidrauski do in the three-asset model, that an increase in the rate of deflation results in a decrease in the excess supply of money. Under this assumption, c_1 is negative. Expression A.49 indicates that the real prices of capital and land decrease (increase) with an increase in deflation (inflation), and the effect of a shock to the rate of deflation on the rate of interest is indeterminate. As shown is the last expresssion of A.50, however, a negative (positive) association between the rate of deflation (inflation) and the interest rate is assumed.

$$\text{(A.48)} \quad \underline{C} = \begin{bmatrix} -(L_3 + L_4) \\ -(J_3 + J_4) \\ -(R_3 + R_4) \end{bmatrix} d\pi_m = \begin{bmatrix} \overset{?}{c}_1 \\ \overset{+}{c}_2 \\ \overset{+}{c}_3 \end{bmatrix} d\pi_m$$

$$\text{(A.49)} \quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \begin{bmatrix} \bar{d}_{11}\bar{c}_1 + \overset{+}{d}_{21}\overset{+}{c}_2 + \overset{+}{d}_{31}\overset{+}{c}_3 \\ \bar{d}_{12}\bar{c}_1 + \overset{+}{d}_{22}\overset{+}{c}_2 + \overset{+}{d}_{32}\overset{+}{c}_3 \\ \overset{+}{d}_{13}\bar{c}_1 + \overset{+}{d}_{23}\overset{+}{c}_2 + \overset{+}{d}_{33}\overset{+}{c}_3 \end{bmatrix} d\pi_m$$

$$\text{(A.50)} \quad \frac{dP_k}{d\pi_m} < 0, \; \frac{dP_L}{d\pi_m} < 0, \; \frac{di}{d\pi_m} < 0$$

The final two comparative statics experiments consider the effects of a shock to the rate of capital gain on capital, equations A.51 through A.53, or a shock to the rate of capital gain on land, equations A.54 through A.56, all else constant. In both cases, the signs of the three elements of the $\underline{C}$ matrix are determinant, but the signs of the effects of the shock to the rate of capital gain on the price of capital, the price of land, and the interest rate cannot be determined without ambiguity.

$$\text{(A.51)} \quad \underline{C} = \begin{bmatrix} -L_5\gamma_3 \\ -J_5\gamma_3 \\ -R_5\gamma_3 \end{bmatrix} d\pi_k = \begin{bmatrix} \overset{+}{c}_1 \\ \overset{-}{c}_2 \\ \overset{+}{c}_3 \end{bmatrix} d\pi_K$$

$$\text{(A.52)} \quad \underline{B} = \frac{\overset{-}{1}}{|\underline{A}|} \begin{bmatrix} \overset{-}{d}_{11}\overset{+}{c}_1 + \overset{+}{d}_{21}\overset{-}{c}_2 + \overset{+}{d}_{31}\overset{+}{c}_3 \\ \overset{-}{d}_{12}\overset{+}{c}_1 + \overset{+}{d}_{22}\overset{-}{c}_2 + \overset{+}{d}_{32}\overset{+}{c}_3 \\ \overset{+}{d}_{13}\overset{+}{c}_1 + \overset{+}{d}_{23}\overset{-}{c}_2 + \overset{+}{d}_{33}\overset{+}{c}_3 \end{bmatrix} d\pi_k$$

$$\text{(A.53)} \quad \frac{dP_k}{d\pi_k} \gtrless 0, \; \frac{dP_L}{d\pi_k} \gtrless 0, \; \frac{di}{d\pi_k} \gtrless 0$$

$$(A.54)\quad \underline{C} = \begin{bmatrix} -L_6\delta_5 \\ -J_6\delta_5 \\ -R_6\delta_5 \end{bmatrix} d\pi_L = \begin{bmatrix} \overset{+}{c}_1 \\ \overset{+}{c}_2 \\ \overset{-}{c}_3 \end{bmatrix} d\pi_L$$

$$(A.55)\quad \underline{B} = \frac{\bar{1}}{|\underline{A}|} \begin{bmatrix} \bar{d}_{11}\overset{+}{c}_1 + \overset{+}{d}_{21}\overset{+}{c}_2 + \overset{+}{d}_{31}\bar{c}_3 \\ \bar{d}_{12}\overset{+}{c}_1 + \overset{+}{d}_{22}\overset{+}{c}_2 + \overset{+}{d}_{32}\bar{c}_3 \\ \overset{+}{d}_{13}\overset{+}{c}_1 + \overset{+}{d}_{23}\overset{+}{c}_2 + \overset{+}{d}_{33}\bar{c}_3 \end{bmatrix} d\pi_L$$

$$(A.56)\quad \frac{dP_k}{d\pi_L} \gtrless 0,\ \frac{dP_L}{d\pi_L} \gtrless 0,\ \frac{di}{d\pi_L} \gtrless 0$$

A summary of these investigations of the properties of comparative statics of the assets markets of the four-asset model is presented in the reduced-form equations for the three unknowns of the $\underline{B}$ vector restated in equations A.57 through A.59. The signs of the respective partial derivatives that were determined without ambiguity in the preceding discussion are shown in each of the reduced-form equations. Of greatest interest to the analyses presented in this dissertation are the signs of the partial derivatives of the three reduced-form equations with respect to the monetary control variable x and the rate of deflation π_m.

$$(A.57)\quad P_k = P_k(\overset{+}{g},\ \bar{x},\ k,\ \ell,\ \bar{\pi}_m,\ \pi_k,\ \pi_L)$$

(A.58) $P_L = P_L(\overset{+}{g}, \overset{-}{x}, k, \ell, \overset{-}{\pi}_m, \pi_k, \pi_L)$

(A.59) $i = i(g, \overset{+}{x}, k, \ell, \overset{-}{\pi}_m, \pi_k, \pi_L)$

APPENDIX B: DATA

Table B.1. Data series used in the empirical model[a]

Year	Nominal deficit ($\$10^9$)	Nominal M1 ($\$10^9$)	Moody's Aaa corp. bond rate (%)	Nominal gross cash rent ($/acre)	Nominal land value ($/acre)	IPCE
1929	1.20	26.6	4.73	4.61	79	35.9
1930	0.30	25.8	4.55	4.48	75	36.6
1931	-2.10	24.1	4.58	4.18	66	32.5
1932	-1.50	21.1	5.01	3.52	55	28.6
1933	-1.30	19.9	4.49	2.79	45	27.8
1934	-2.90	21.9	4.00	3.04	48	29.6
1935	-2.60	25.9	3.60	3.13	50	28.9
1936	-3.60	29.6	3.24	3.42	53	28.9
1937	-0.40	30.9	3.26	3.48	54	30.3
1938	-2.10	30.5	3.19	3.53	54	30.9
1939	-2.20	34.2	3.01	3.43	52	30.5
1940	-1.30	39.7	2.84	3.51	52	30.9
1941	-5.10	46.5	2.77	3.59	53	33.2
1942	-33.10	55.4	2.83	4.01	59	36.7
1943	-46.50	72.2	2.73	4.46	65	40.1
1944	-54.50	85.3	2.72	4.82	73	42.4
1945	-42.10	99.2	2.62	5.10	78	44.1
1946	3.50	106.5	2.53	5.43	87	47.8
1947	13.40	111.8	2.61	6.08	97	52.9
1948	8.30	112.3	2.82	6.66	105	56.0
1949	-2.60	111.1	2.66	6.80	110	55.8
1950	9.20	114.1	2.62	7.06	111	56.9
1951	6.50	119.2	2.86	7.88	131	60.6
1952	-3.70	125.2	2.96	8.47	142	62.0
1953	-7.10	128.3	3.20	8.81	139	63.2
1954	-6.00	130.3	2.90	9.02	141	63.7
1955	4.40	134.4	3.06	9.20	147	64.4
1956	6.10	136.0	3.36	9.90	151	65.6
1957	2.30	136.8	3.89	10.70	160	67.8
1958	-10.30	138.4	3.79	10.79	165	69.2
1959	-1.10	141.4	4.38	11.62	178	70.6
1960	3.00	141.4	4.41	11.83	181	71.9
1961	-3.90	144.3	4.35	11.95	180	72.6
1962	-4.20	147.9	4.33	12.17	184	73.7
1963	0.30	152.4	4.26	12.82	191	74.8
1964	-3.30	158.3	4.40	13.57	201	75.9
1965	0.50	165.1	4.49	14.00	214	77.2
1966	-1.80	172.7	5.13	15.73	236	79.4
1967	-13.20	179.5	5.51	16.51	251	81.4
1968	-6.00	192.1	6.18	17.95	274	84.6
1969	8.40	203.5	7.03	18.87	287	88.4

Table B.1. continued

Year	Nominal deficit ($\$10^9$)	Nominal M1 ($\$10^9$)	Moody's Aaa corp. bond rate (%)	Nominal gross cash rent ($/acre)	Nominal land value ($/acre)	IPCE
1970	-12.40	211.2	8.04	19.48	298	92.5
1971	-22.00	225.5	7.39	20.47	3021	96.5
1972	-16.80	241.6	7.21	21.15	309	100.0
1973	-5.60	259.2	7.44	22.86	344	105.7
1974	-11.60	272.3	8.57	28.83	440	116.4
1975	-69.40	285.0	8.83	33.77	519	125.3
1976	-53.50	301.0	8.43	38.69	650	131.7
1977	-46.00	324.0	8.02	44.39	801	139.3
1978	-29.30	350.5	8.73	46.73	897	149.1
1979	-16.10	377.6	9.63	51.83	1036	162.5
1980	-61.30	401.1	11.94	55.59	1182	179.0
1981	-63.80	429.4	14.17	59.60	1248	194.5
1982	-145.90	457.6	13.79	61.97	1231	206.0
1983	-179.40	508.9	12.04	61.60	1106	213.6
1984	-172.90	544.5	12.71	62.03	1054	220.4
1985	-200.00	593.9	8.65	57.14	809	227.2

[a]These data series are described in detail in Chapter Five.

APPENDIX C:

IMPULSE RESPONSES FROM THE ESTIMATION OF THE VAR MODEL OVER THE PERIOD 1935-1985

Table C.1. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Deficit at step 1

Step	Deficit	M1	RRate	Returns	Value
	Response in:				
1	8.60006	0.312697D-02	0.691224D-01	-0.157171D-02	-0.134457D-01
2	3.10547	0.171728D-03	0.697922	-0.909499D-02	-0.163788D-01
3	-0.210868	0.371028D-02	0.174228	-0.464066D-02	-0.113366D-01
4	-0.314086D-01	0.118856D-02	-0.428064	-0.130425D-01	-0.211426D-01
5	-1.34863	-0.139938D-01	0.164660	-0.206352D-02	-0.170733D-01
6	3.60875	-0.626258D-02	0.639057	-0.741812D-02	-0.883209D-02
7	0.721249	-0.693623D-02	0.723449	0.186126D-02	-0.421344D-03
8	-1.14436	-0.215603D-02	0.122167	0.303341D-02	0.804886D-03
9	0.611541	-0.344691D-02	-0.289733	0.238228D-02	0.887447D-02
10	-1.69614	-0.309130D-02	0.263240D-01	0.727288D-02	0.111751D-01
11	-0.584018	-0.356452D-02	0.137639	0.551476D-02	0.119997D-01
12	-0.908219	-0.377081D-03	0.875872D-01	0.508968D-03	0.770954D-02
13	-2.48112	-0.103843D-02	-0.880851D-01	0.214813D-02	0.887075D-02
14	-0.836997	0.314174D-02	-0.148948	-0.669244D-03	0.305276D-02
15	-0.950364	0.221825D-02	-0.124483D-01	0.768632D-03	0.220255D-02
16	0.213099D-01	0.313726D-02	0.334219D-01	0.202138D-03	-0.801810D-03
17	0.774304	0.184863D-02	-0.104081D-01	-0.229301D-02	-0.403886D-02
18	0.237194	0.785443D-03	0.388761D-01	-0.509888D-03	-0.616144D-02
19	1.37085	0.145150D-02	0.519664D-01	-0.245972D-02	-0.622252D-02
20	0.928649	0.440386D-03	0.119820	-0.157207D-02	-0.659700D-02
21	0.495337	-0.408911D-03	0.957183D-01	-0.163409D-02	-0.572082D-02
22	0.727488	-0.525078D-03	0.699953D-01	-0.186334D-02	-0.408371D-02
23	-0.368836D-01	-0.512733D-03	0.811084D-01	-0.201483D-03	-0.142135D-02
24	0.451967D-01	-0.347935D-03	0.375946D-01	0.684664D-03	0.101401D-02
25	-0.178250	0.395100D-04	-0.125370D-01	0.767260D-03	0.286467D-02
26	-0.688052	-0.313707D-03	-0.585368D-01	0.237837D-02	0.512651D-02
27	-0.430696	0.521572D-03	-0.100208	0.175879D-02	0.539692D-02
28	-0.673062	0.213185D-03	-0.990535D-01	0.223225D-02	0.572399D-02
29	-0.567941	0.738169D-03	-0.108377	0.159389D-02	0.483016D-02
30	-0.379852	0.725760D-03	-0.109910	0.755763D-03	0.342699D-02

Table C.2. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in M1 at step 1

Step	Response in: Deficit	M1	RRate	Returns	Value
1	0.0	0.233157D-01	-0.953101	0.218789D-02	0.584966D-03
2	0.518082	0.109317D-01	-0.827668	0.626792D-02	0.137475D-01
3	0.641731	0.754580D-02	-0.325759	0.301928D-02	-0.774503D-04
4	0.445063	0.182845D-02	-0.313248	0.961971D-03	0.450062D-02
5	0.630612	0.758414D-02	-0.232281	-0.209962D-02	0.213389D-02
6	-0.426581	0.563736D-02	-0.529607	-0.139599D-02	0.276897D-02
7	-0.814477	0.416894D-02	-0.550212	-0.136019D-04	-0.130159D-02
8	0.212944	0.216591D-02	-0.419196	-0.176411D-02	0.297986D-02
9	0.198863	0.117664D-03	-0.233796	0.195480D-02	0.965649D-03
10	0.657336	-0.184060D-02	-0.198389	-0.112463D-02	-0.137335D-02
11	0.917189	-0.232866D-02	-0.155093	-0.622745D-03	-0.986330D-03
12	0.416576	-0.141987D-02	-0.131607	-0.121601D-02	-0.128664D-02
13	0.417165	-0.312955D-02	-0.573409D-01	-0.514005D-03	-0.325499D-02
14	0.569479	-0.283175D-02	0.196798D-01	-0.286500D-02	-0.433395D-02
15	0.362539	-0.419350D-02	0.104602	-0.158279D-02	-0.330196D-02
16	0.372276	-0.279356D-02	0.141364	-0.258530D-02	-0.500415D-02
17	0.286577	-0.338883D-02	0.146702	-0.128930D-02	-0.350138D-02
18	0.333037	-0.202562D-02	0.143733	-0.141297D-02	-0.301964D-02
19	0.184983	-0.294174D-02	0.136394	-0.264190D-03	-0.167340D-02
20	0.875645D-01	-0.219175D-02	0.145509	-0.171084D-03	-0.168762D-02
21	0.108246	-0.231279D-02	0.134746	0.131866D-03	0.158196D-03
22	-0.119439	-0.141810D-02	0.125304	0.321606D-03	0.163144D-03
23	-0.254170	-0.139215D-02	0.904980D-01	0.427814D-03	0.992887D-03
24	-0.263915	-0.479014D-03	0.758220D-01	0.412235D-03	0.110526D-02
25	-0.343781	-0.248750D-03	0.574508D-01	0.593448D-03	0.171714D-02
26	-0.291627	0.248380D-03	0.433383D-01	0.640512D-03	0.126036D-02
27	-0.231601	0.462925D-03	0.227007D-01	0.400757D-03	0.132277D-02
28	-0.198845	0.734188D-03	0.128255D-01	0.584973D-03	0.103455D-02
29	-0.104300	0.892099D-03	-0.103115D-02	0.264701D-03	0.625714D-03
30	-0.637646D-01	0.827843D-03	-0.335624D-02	0.299478D-03	0.235027D-03

Table C.3. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in RRate at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	0.0	0.0	1.21282	0.403109D-02	0.100730D-01
2	1.98345	0.616996D-02	0.650188	0.192062D-03	-0.286035D-02
3	-0.642064	0.450569D-02	-0.203616	-0.617426D-02	-0.515376D-02
4	-2.15481	0.312250D-02	-0.288519	-0.762811D-03	0.202993D-02
5	-0.690587	0.540353D-02	-0.158889	0.150868D-02	-0.709597D-03
6	-0.472621	-0.227294D-02	0.180130	0.354192D-02	-0.120996D-02
7	1.40342	-0.103714D-02	0.120953	-0.205848D-02	0.953319D-03
8	-0.803410D-01	-0.133727D-02	-0.183999D-01	0.143189D-02	0.261961D-02
9	-0.795052	0.236092D-02	-0.668090D-01	0.290462D-02	0.130016D-02
10	0.745662	0.321455D-02	-0.145645	0.102901D-02	0.449946D-02
11	-0.613317	0.117408D-02	-0.855760D-01	0.149771D-02	0.311099D-02
12	-0.562416	-0.774236D-03	-0.820353D-01	0.366120D-03	0.144326D-02
13	0.364758D-01	0.157462D-02	-0.359284D-01	-0.108545D-02	0.563309D-03
14	-0.462887	0.163025D-02	-0.292584D-01	0.679493D-03	0.212632D-02
15	0.100425	0.198587D-02	-0.104614	-0.526481D-03	-0.493163D-03
16	-0.108752	0.552843D-03	-0.106747	-0.336112D-03	-0.414945D-03
17	0.921163D-01	0.641098D-03	-0.495963D-01	0.523906D-03	-0.124719D-03
18	0.564519	0.379102D-03	-0.214568D-01	-0.490838D-03	-0.107173D-02
19	0.139057	-0.547037D-03	0.167845D-02	-0.505719D-04	-0.165908D-02
20	0.336442	-0.281684D-03	-0.216498D-01	-0.101466D-02	-0.127061D-02
21	0.131918	-0.388378D-03	-0.201053D-03	-0.504413D-03	-0.132868D-02
22	-0.190297D-01	-0.493943D-03	0.168180D-01	-0.243775D-03	-0.114730D-02
23	0.254233	-0.515593D-03	0.173469D-01	-0.610398D-03	-0.648167D-03
24	-0.740057D-01	-0.591968D-03	0.226753D-01	-0.130826D-03	-0.188640D-03
25	-0.444138D-01	-0.555914D-03	0.827127D-02	0.224731D-03	0.196845D-03
26	0.511178D-01	-0.213769D-03	0.326733D-02	-0.217825D-05	0.414661D-03
27	-0.139494	-0.471916D-03	0.490956D-02	0.567980D-03	0.944304D-03
28	-0.239580D-01	-0.242770D-03	-0.382007D-02	0.148463D-03	0.614057D-03
29	-0.108110	-0.369183D-03	0.131757D-02	0.221378D-03	0.627206D-03
30	-0.100531	-0.106764D-03	0.427567D-02	0.170860D-03	0.475957D-03

Table C.4. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Returns at step 1

Step	Response in: Deficit	M1	RRate	Returns	Value
1	0.0	0.0	0.0	0.237107D-01	0.306736D-01
2	3.01849	0.513458D-02	-0.604644D-01	0.614260D-02	0.132083D-01
3	-0.740122	-0.833373D-03	-0.465037	0.660938D-02	0.134679D-01
4	-2.26750	0.804437D-03	-0.454990	0.131555D-02	0.118640D-01
5	-2.07230	0.285614D-02	-0.216602	-0.269221D-02	0.561265D-02
6	-2.70956	0.264799D-02	-0.109632	-0.609442D-03	-0.110216D-02
7	0.382203	0.177204D-02	-0.922980D-01	-0.639247D-02	-0.250919D-02
8	0.270029D-01	0.265076D-02	-0.698153D-03	-0.264140D-02	-0.490397D-02
9	0.423247	0.297596D-02	-0.512626D-01	0.699534D-03	-0.569634D-02
10	2.52799	0.256364D-02	-0.549954D-01	-0.166769D-02	-0.730309D-02
11	1.36686	-0.152849D-02	0.145021D-01	-0.347998D-03	-0.651312D-02
12	1.43213	-0.327071D-02	0.824351D-01	-0.154801D-02	-0.787821D-02
13	1.14184	-0.277412D-02	0.170073	-0.331181D-02	-0.703150D-02
14	0.508851D-01	-0.261440D-02	0.181582	-0.121325D-02	-0.368232D-02
15	0.173522	-0.160395D-02	0.943787D-01	-0.242759D-02	-0.237026D-02
16	-0.659754	-0.200073D-02	0.736306D-01	0.112909D-03	0.782093D-03
17	-0.546765	-0.567436D-03	0.367019D-01	0.148277D-02	0.403602D-02
18	-0.301197	-0.310434D-03	-0.687854D-02	0.214625D-02	0.561949D-02
19	-0.785279	-0.428925D-03	-0.506890D-01	0.300315D-02	0.604879D-02
20	-0.417250	-0.115366D-03	-0.100740	0.219062D-02	0.613241D-02
21	-0.556724	0.348604D-03	-0.810046D-01	0.173347D-02	0.469033D-02
22	-0.544204	0.272341D-03	-0.630641D-01	0.121404D-02	0.303838D-02
23	-0.105795	0.770869D-03	-0.455657D-01	-0.554695D-03	0.608246D-03
24	-0.218014	0.536848D-03	-0.106332D-01	-0.685042D-03	-0.947885D-03
25	0.152692	0.901790D-03	0.964363D-02	-0.124047D-02	-0.275317D-02
26	0.415295	0.727180D-03	0.338163D-01	-0.156224D-02	-0.371489D-02
27	0.413481	0.364912D-03	0.539063D-01	-0.114242D-02	-0.401950D-02
28	0.619055	0.686965D-04	0.538923D-01	-0.133542D-02	-0.398825D-02
29	0.456071	-0.358475D-03	0.654291D-01	-0.814457D-03	-0.338073D-02
30	0.371700	-0.522691D-03	0.594473D-01	-0.508797D-03	-0.220541D-02

Table C.5. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Value at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	0.0	0.0	0.0	0.0	0.180760D-01
2	-3.63536	0.316992D-03	-0.169588	0.776986D-02	0.110736D-01
3	-1.81288	0.186244D-02	-0.580259	0.343311D-02	0.113554D-01
4	-0.120405	-0.125774D-02	-0.366783	0.452136D-02	0.146335D-01
5	-1.29281	-0.110332D-02	-0.131621	0.385202D-02	0.928229D-02
6	-0.358531	-0.148473D-02	-0.118922	0.199695D-02	0.296909D-02
7	0.109768	0.181174D-02	-0.125941	-0.303560D-02	-0.678615D-03
8	0.242952D-01	-0.930482D-03	-0.746982D-01	-0.101816D-02	-0.346227D-02
9	0.922514	0.351223D-03	0.700613D-01	-0.504032D-02	-0.112299D-01
10	1.02558	-0.151496D-02	0.219123	-0.357913D-02	-0.974788D-02
11	1.40209	0.364387D-03	0.231285	-0.460009D-02	-0.113976D-01
12	1.16399	-0.252937D-02	0.195192	-0.335706D-02	-0.107324D-01
13	0.980687	-0.176122D-02	0.216661	-0.246720D-02	-0.899149D-02
14	1.01879	-0.227024D-02	0.209189	-0.108726D-02	-0.371126D-02
15	0.213346	-0.195697D-02	0.189274	0.462501D-03	-0.209070D-02
16	-0.132375	-0.259992D-02	0.908043D-01	0.934079D-03	0.192936D-02
17	-0.438856	-0.131923D-02	0.466590D-01	0.168005D-02	0.469218D-02
18	-0.987663	-0.922306D-03	0.160651D-02	0.281004D-02	0.722314D-02
19	-0.932453	0.137856D-03	-0.488618D-01	0.276580D-02	0.739690D-02
20	-1.01024	0.628504D-03	-0.962172D-01	0.227514D-02	0.787052D-02
21	-0.989514	0.112716D-02	-0.112813	0.245475D-02	0.664543D-02
22	-0.610976	0.165813D-02	-0.116343	0.121689D-02	0.445676D-02
23	-0.388106	0.161616D-02	-0.879037D-01	0.842155D-03	0.233805D-02
24	-0.231358D-01	0.177179D-02	-0.701427D-01	-0.414834D-03	-0.161656D-03
25	0.212165	0.124389D-02	-0.367420D-01	-0.937422D-03	-0.253703D-02
26	0.425835	0.109391D-02	0.139266D-02	-0.160446D-02	-0.424567D-02
27	0.659887	0.587723D-03	0.348397D-01	-0.179925D-02	-0.497245D-02
28	0.634936	0.242216D-03	0.596041D-01	-0.184131D-02	-0.538591D-02
29	0.608170	-0.329288D-03	0.656920D-01	-0.147362D-02	-0.462479D-02
30	0.521757	-0.406771D-03	0.660483D-01	-0.114740D-02	-0.350059D-02

APPENDIX D:

IMPULSE RESPONSES FROM THE ESTIMATION OF THE VAR MODEL OVER THE PERIOD 1946-1985

Table D.1. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Deficit at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	6.82666	-0.199685D-02	0.399216	0.180256D-02	-0.532126D-02
2	2.51287	0.175812D-03	0.495510	-0.459262D-02	-0.142990D-01
3	-1.03926	-0.186090D-02	0.213653	-0.529854D-02	-0.111564D-02
4	-1.60825	0.842199D-04	-0.275836	-0.373989D-02	-0.903191D-02
5	-0.733531	-0.222063D-02	-0.242480	-0.233717D-02	-0.242692D-02
6	1.15097	-0.190326D-02	0.141027	-0.166100D-02	-0.335665D-02
7	0.674030	-0.259020D-02	0.375009	0.147388D-02	0.148469D-02
8	0.161520	0.112954D-02	0.692252D-01	0.144143D-02	-0.168122D-02
9	0.296448	0.922481D-03	-0.620753D-01	0.250374D-02	0.628206D-02
10	0.755100	0.894231D-03	-0.674445D-01	0.238797D-02	-0.116903D-02
11	1.30612	-0.175777D-02	0.982171D-01	-0.754990D-03	-0.280730D-03
12	0.247480	0.334252D-03	0.637894D-01	-0.283239D-02	-0.359021D-02
13	-1.29839	-0.658818D-03	-0.219116D-01	-0.216929D-02	0.834511D-03
14	-1.16376	0.351869D-03	-0.137739	-0.198149D-02	-0.441881D-02
15	-0.159814	-0.122146D-02	0.129789D-01	-0.168530D-03	0.168387D-02
16	0.539736	-0.175942D-03	0.111745	0.755284D-03	-0.243464D-02
17	0.812394	-0.750683D-03	0.152677	0.123313D-02	0.158019D-02
18	0.646436	0.141688D-02	0.225107D-01	0.741901D-03	-0.124057D-02
19	0.228640	0.615314D-04	-0.677363D-02	0.735946D-03	0.223495D-02
20	0.172377	0.465457D-03	-0.628461D-01	-0.589604D-03	-0.311378D-02
21	-0.221585D-01	-0.965538D-03	-0.112671D-02	-0.121913D-02	0.936603D-03
22	-0.509646	0.171877D-03	-0.342702D-01	-0.130649D-02	-0.236275D-02
23	-0.619130	-0.828695D-03	-0.156290D-01	-0.436012D-03	0.155233D-02
24	-0.257616	0.452729D-03	-0.343489D-01	0.136001D-03	-0.115951D-02
25	0.133382	-0.574891D-03	0.467747D-01	0.123341D-02	0.278405D-02
26	0.470861	0.531262D-03	0.336238D-01	0.984780D-03	-0.117917D-02
27	0.475865	-0.195555D-03	0.516118D-01	0.717511D-03	0.216811D-02
28	0.178787	0.850724D-03	-0.169809D-01	-0.916852D-04	-0.155211D-02
29	-0.903176D-01	-0.408146D-03	-0.122112D-01	-0.479198D-03	0.923857D-03
30	-0.199598	0.310122D-03	-0.440857D-01	-0.110915D-02	-0.246243D-02

Table D.2. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in M1 at step 1

Step	Deficit	M1	RRate	Returns	Value
	Response in:				
1	0.0	0.102698D-01	-0.357875	-0.812687D-02	-0.670325D-02
2	-4.41541	0.407183D-02	-0.300643	0.361479D-02	0.121465D-01
3	-2.74799	0.768643D-03	-0.442062	0.503265D-02	-0.466136D-02
4	0.788390	-0.952881D-03	-0.225139	0.339095D-02	0.125128D-01
5	-0.285884	0.418173D-02	-0.310039	0.880742D-02	0.114566D-01
6	-0.626307	-0.195662D-04	-0.201672	0.646595D-02	0.154929D-01
7	-0.956701	0.444803D-02	-0.333880	0.320256D-02	0.623775D-02
8	-2.29912	0.640273D-03	-0.277127	0.453703D-02	0.174912D-01
9	-1.85578	0.155015D-02	-0.314580	0.105856D-02	-0.283359D-03
10	-0.661740	-0.965195D-03	-0.756740D-01	0.114360D-03	0.898850D-02
11	-0.760154	0.213196D-02	-0.106792D-01	-0.690732D-03	-0.159577D-02
12	-0.813096	-0.948972D-03	0.105933	0.997463D-04	0.349662D-02
13	0.127480	0.227603D-02	-0.167113D-01	-0.964575D-03	-0.586069D-02
14	0.372518	-0.505597D-03	0.107003	0.293112D-03	0.339210D-02
15	0.630181	0.136727D-02	0.202871D-01	-0.413707D-03	-0.764205D-02
16	0.746595	-0.111002D-02	0.810268D-01	-0.958148D-03	0.152021D-02
17	-0.424881D-01	0.168850D-02	-0.541785D-01	-0.115564D-02	-0.503889D-02
18	-0.564690	-0.129050D-02	-0.423260D-01	0.190250D-04	0.335198D-02
19	-0.321821	0.102466D-02	-0.135402	-0.357362D-03	-0.366644D-02
20	-0.281903	-0.130590D-02	-0.825100D-02	0.128437D-02	0.643255D-02
21	-0.184167	0.101080D-02	-0.601173D-01	0.126066D-02	-0.161596D-02
22	0.900971D-03	-0.895099D-03	0.133982D-01	0.171515D-02	0.639755D-02
23	0.250205D-02	0.164946D-02	-0.617577D-01	0.103946D-02	-0.927359D-03
24	-0.692936D-01	-0.828513D-03	0.157986D-01	0.107130D-02	0.503647D-02
25	0.393860D-01	0.118561D-02	-0.495455D-01	-0.465674D-03	-0.344335D-02
26	-0.127983	-0.965983D-03	0.370441D-01	-0.497940D-03	0.338932D-02
27	-0.280391	0.974436D-03	-0.319143D-01	-0.111125D-02	-0.445446D-02
28	-0.186922	-0.112006D-02	0.369112D-01	-0.575721D-03	0.219468D-02
29	-0.822227D-02	0.953162D-03	-0.134003D-01	-0.641967D-03	-0.407931D-02
30	0.105398	-0.105206D-02	0.642093D-01	0.348041D-03	0.264347D-02

Table D.3. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in RRate at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	0.0	0.0	0.883951	-0.118233D-02	-0.722199D-02
2	0.560089	-0.820224D-03	0.559432	-0.107583D-01	-0.214437D-01
3	1.45165	0.162716D-02	0.867739D-01	-0.378704D-02	-0.128562D-01
4	2.78209	0.273312D-02	0.209915	-0.790912D-02	-0.136805D-01
5	1.25760	-0.287972D-03	0.306570	-0.534607D-02	-0.181103D-01
6	0.712292	-0.117778D-02	-0.133552D-01	-0.180215D-02	-0.101238D-01
7	-0.170002	-0.184513D-03	-0.978192D-01	-0.236910D-02	0.701419D-03
8	-1.63060	0.574280D-03	-0.355110	0.574634D-02	0.470216D-02
9	0.153977	-0.982110D-03	-0.350902	0.532829D-02	0.863353D-02
10	0.122265	0.681918D-03	-0.947610D-01	0.514533D-02	0.126215D-01
11	-1.21072	0.411413D-03	-0.123613	0.709273D-02	0.133558D-01
12	-0.912148	0.102607D-02	-0.244592	0.287972D-02	0.711108D-02
13	-0.830552	0.137456D-02	-0.160027	0.175125D-02	0.937790D-02
14	-0.812570	0.262713D-03	-0.290757D-01	0.273500D-03	0.187227D-02
15	-0.246191	-0.702337D-03	0.802486D-01	-0.250318D-02	-0.269811D-02
16	-0.152149	0.629747D-03	0.105548	-0.309894D-02	-0.276863D-02
17	-0.420769	0.357933D-04	0.112221	-0.203012D-02	-0.370276D-02
18	0.380894	-0.740756D-05	0.721071D-01	-0.171133D-02	-0.668899D-02
19	1.07545	-0.147829D-03	0.122585	-0.127483D-02	-0.308519D-02
20	0.693877	0.996897D-04	0.106083	-0.194083D-03	-0.350766D-02
21	0.491852	-0.266503D-03	0.145373D-01	-0.107944D-03	-0.198348D-02
22	0.207983	0.468756D-03	-0.672536D-01	-0.165302D-03	-0.350472D-03
23	-0.342405	-0.196966D-03	-0.788033D-01	0.837259D-03	0.207347D-02
24	-0.316750	-0.297401D-03	-0.920005D-01	0.663514D-03	0.736441D-03
25	-0.270184	-0.275003D-03	-0.547081D-01	0.780215D-03	0.340110D-02
26	-0.460043	0.234374D-03	-0.444123D-01	0.128011D-02	0.276479D-02
27	-0.273656	-0.843680D-04	-0.276739D-01	0.118849D-02	0.258629D-02
28	0.463641D-01	0.425482D-03	-0.116369D-01	0.670845D-03	0.131292D-02
29	0.623662D-01	0.691080D-04	0.301846D-01	0.404282D-03	0.138861D-02
30	0.820241D-01	0.201827D-03	0.220840D-01	-0.385581D-03	-0.128111D-02

Table D.4. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Returns at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	0.0	0.0	0.0	0.205758D-01	0.265946D-01
2	2.42365	-0.129464D-02	-0.141158D-01	0.453843D-02	0.197382D-02
3	1.97717	-0.100212D-03	-0.137620	0.717842D-02	0.113232D-01
4	1.36096	0.990709D-03	-0.700059D-01	-0.988714D-03	0.792739D-02
5	-2.43693	-0.107173D-02	0.119957	-0.766998D-02	-0.455570D-02
6	-3.14026	-0.298587D-03	-0.239262	-0.497003D-02	-0.661244D-02
7	-1.34087	-0.231521D-02	0.559596D-01	-0.748101D-02	-0.318709D-02
8	-0.466918	-0.104127D-02	0.277366	-0.779745D-03	-0.836747D-02
9	2.42568	-0.197771D-02	0.364102	0.106468D-03	-0.516844D-02
10	2.73026	0.163039D-02	0.377226	-0.177829D-03	-0.565672D-02
11	1.51739	0.804873D-03	0.182444	0.264575D-02	-0.378892D-03
12	1.48779	0.713786D-03	-0.676898D-01	-0.138696D-02	-0.790381D-02
13	0.517966	-0.557283D-03	-0.828171D-01	-0.209182D-02	-0.192072D-03
14	-0.845607	-0.640711D-03	-0.125690	-0.239483D-02	-0.294885D-02
15	-1.49040	-0.192694D-02	-0.117665	-0.191403D-02	0.388823D-03
16	-1.28564	0.673367D-04	-0.140891	0.186256D-03	0.211859D-02
17	-0.744156	-0.796264D-03	-0.772086D-02	0.297559D-02	0.654802D-02
18	0.431848	0.371895D-03	0.294283D-01	0.377747D-02	0.197073D-02
19	1.26070	0.201492D-03	0.108823	0.291543D-02	0.546778D-02
20	0.762569	0.145181D-02	0.600232D-01	0.138472D-02	0.370317D-03
21	0.212193	0.647114D-04	0.362680D-03	-0.652283D-03	0.166448D-03
22	-0.184550	0.597307D-03	-0.642206D-01	-0.302252D-02	-0.413063D-02
23	-0.754354	-0.915662D-03	-0.113393D-01	-0.282923D-02	-0.144048D-02
24	-0.692098	-0.491703D-03	-0.134386D-01	-0.251433D-02	-0.496131D-02
25	-0.267735	-0.948062D-03	0.509276D-01	-0.949555D-03	-0.233295D-03
26	0.122604	0.345159D-03	0.486250D-01	0.822229D-03	-0.125326D-02
27	0.609954	-0.305291D-03	0.745487D-01	0.193704D-02	0.173597D-02
28	0.908409	0.822577D-03	0.269387D-01	0.154841D-02	-0.418074D-03
29	0.583978	0.548851D-04	0.197537D-01	0.103802D-02	0.233323D-02
30	0.512544D-01	0.557035D-03	-0.580183D-01	-0.263291D-03	-0.127881D-02

Table D.5. The response at steps 1 through 30 of each variable of the VAR to a one-standard deviation shock in Value at step 1

	Response in:				
Step	Deficit	M1	RRate	Returns	Value
1	0.0	0.0	0.0	0.0	0.131518D-01
2	-1.28316	0.380801D-02	-0.351818	0.664862D-02	0.428922D-03
3	0.384168	-0.197646D-02	-0.220576	0.213185D-02	0.715562D-02
4	0.630089	-0.264395D-02	0.925209D-01	0.116637D-02	0.308253D-02
5	-0.695562	-0.195564D-02	0.855785D-01	0.213297D-02	0.657967D-02
6	-0.645898	0.155074D-02	-0.166510	-0.270802D-02	-0.429319D-02
7	-0.800103	0.692657D-04	-0.250606D-01	-0.215324D-03	0.716388D-02
8	-0.324311	0.995334D-04	0.649672D-01	-0.655665D-03	-0.615549D-02
9	0.716779	-0.206406D-02	0.189764	-0.157655D-02	-0.197929D-02
10	0.795004	0.144724D-02	0.107760	-0.150452D-02	-0.437163D-02
11	0.123941	-0.699277D-03	0.120204	-0.287713D-03	0.199186D-03
12	0.535851	0.895402D-03	-0.298169D-01	-0.107760D-02	-0.754655D-02
13	0.653922	-0.985709D-03	0.589091D-01	-0.921286D-03	0.184889D-02
14	-0.727249D-01	0.499831D-03	-0.211851D-02	-0.426272D-03	-0.438946D-02
15	-0.113904	-0.137995D-02	-0.154072D-01	-0.103143D-03	0.186448D-02
16	-0.125655	0.103718D-02	-0.861374D-01	-0.222604D-03	-0.144995D-02
17	-0.395454	-0.961017D-03	-0.470874D-02	0.152962D-02	0.506939D-02
18	0.196214D-01	0.545910D-03	-0.512967D-01	0.805751D-03	-0.193217D-02
19	0.178608	-0.656111D-03	0.292879D-01	0.970238D-03	0.500610D-02
20	-0.762895D-01	0.108300D-02	-0.240490D-01	0.647945D-03	-0.107231D-02
21	-0.486843D-01	-0.756221D-03	0.135239D-01	0.286365D-03	0.268284D-02
22	0.469372D-01	0.955855D-03	-0.324297D-01	-0.727420D-03	-0.267282D-02
23	-0.151626	-0.825273D-03	0.413235D-01	-0.361334D-03	0.217305D-02
24	-0.992277D-01	0.545391D-03	-0.122869D-01	-0.906976D-03	-0.405203D-02
25	0.206278D-01	-0.788766D-03	0.405794D-01	-0.482250D-03	0.167824D-02
26	0.802669D-02	0.739441D-03	-0.165215D-02	-0.310738D-03	-0.298243D-02
27	0.114998	-0.823649D-03	0.419254D-01	0.285628D-03	0.166765D-02
28	0.259821	0.750974D-03	-0.103222D-01	-0.942756D-04	-0.262003D-02
29	0.115961	-0.612041D-03	0.305720D-01	0.416810D-03	0.253689D-02
30	0.338611D-01	0.674969D-03	-0.338057D-01	-0.411831D-04	-0.238471D-02